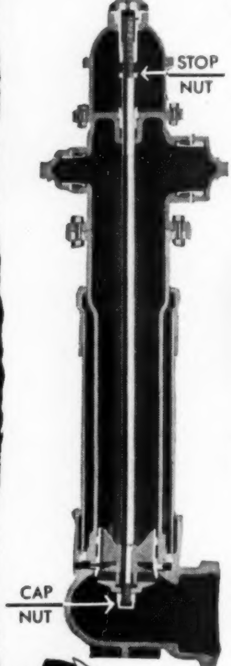
NOVEMBER 1951

Journal

VOL. 43 • NO. 11

AMERICAN WATER WORKS ASSOCIATION

In this issue



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Journal A.W.W.A. is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 521 Fifth Ave., New York 17, N. Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the Act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918.

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Directory of Professional Services—pp. 25-29

COMING MEETINGS

November **7–9**—Virginia Section at Hotel Roanoke, Roanoke. Secretary: W. H. Shewbridge, Asst. Engr., State Dept. of Health, 708 State Office Bldg., Richmond 19, Va.

12–14—North Carolina Section at Robert E. Lee Hotel, Winston-Salem, N.C. Secretary: E. C. Hubbard, Principal San. Engr., State Board of Health, Raleigh, N.C.

A.W.W.A. 1952 ANNUAL CONFERENCE
Kansas City, Mo.
May 4–9

Reservation forms have been mailed to all members, and all reservations will be cleared through the A.W.W.A. office. The hotels have agreed to accept no reservations for the 1952 Conference except as they are requested on the standard form prepared by the A.W.W.A.

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All Technical Sessions and Exhibits at Municipal Auditorium

January 13, 1952 —New York Section Midwinter Luncheon at Park Sheraton Hotel, New York. Secretary: R. K. Blanchard, 50 W. 50 St., New York 20, N.Y.

Journal

AMERICAN WATER WORKS ASSOCIATION

November 1951

Vol. 43 • No. 11

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Departments

Indexed annually in December; and regularly by *Industrial Arts Index and Engineering Index*.

Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

All correspondence relating to the publication of papers should be addressed to:

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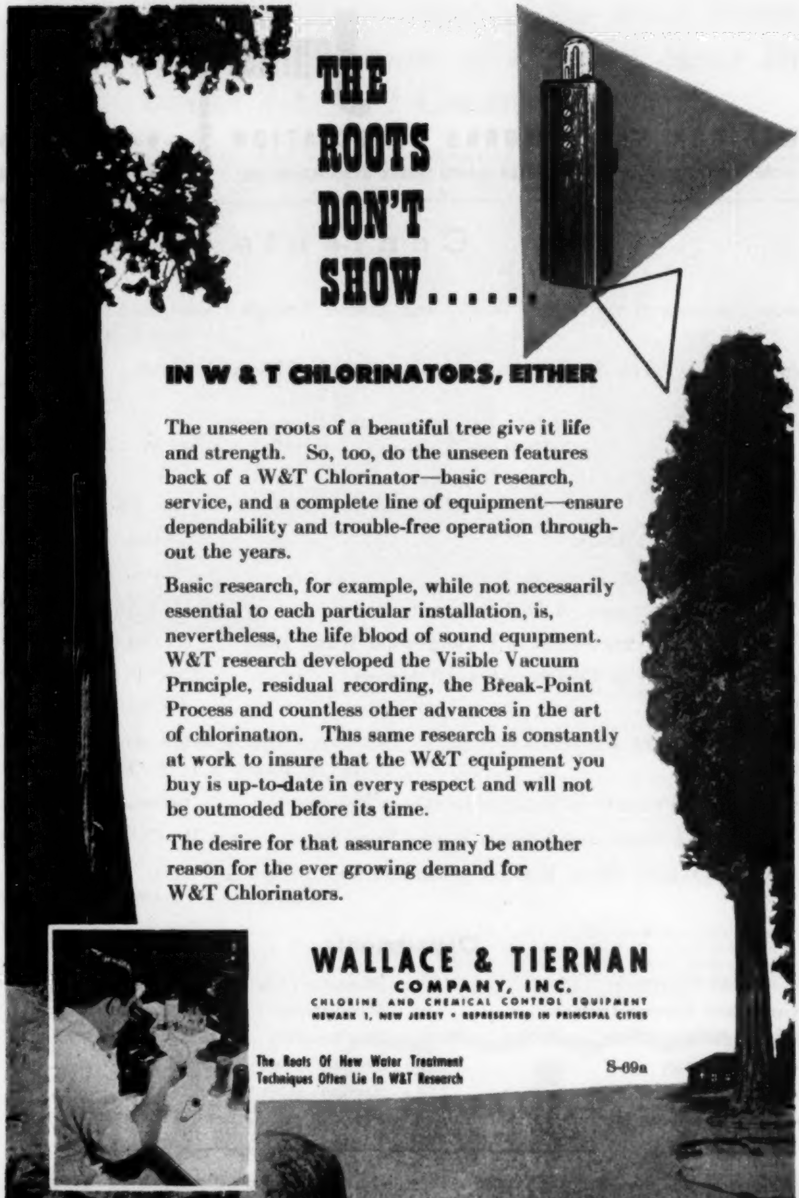
$7.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies to members—50 cents; single copies to non-members—75 cents.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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 43 • NOVEMBER 1951 • NO. 11

Mutual Interests of the Water Works and Atomic Energy Industries

By Arthur E. Gorman

A paper presented on Sept. 26, 1951, at the Wisconsin Section Meeting, Milwaukee, Wis., by Arthur E. Gorman, San. Engr., San. Eng. Div., Atomic Energy Commission, Washington, D.C.

WELL managed water utilities have traditionally kept abreast of the needs of their customers by prudent planning, based on knowledge of the service to be rendered and the changing requirements of the consumer. Industrial customers usually require more specialized consideration than do domestic customers, because both the qualitative and quantitative needs of the former may vary widely and are often subject to sudden changes. Good liaison between industrial and water utility management, complemented by an interchange of technical skill and experience, facilitates the rendering of highly satisfactory service. This mutually advantageous arrangement may be concerned with certain aspects of water service in a delicate manufacturing process, or with the problem of preventing interconnections between a plant auxiliary supply and the public water system, or with industrial waste-disposal practices that constitute a potential hazard to the water supply.

These are common producer-consumer relationships which exist in thousands of communities and with tens of thousands of both new and established industries. Usually the operation and products of these industries are such that they need no special security supervision and control either for patent protection or in the interest of the national defense.

The atomic energy industry is an exception to this rule and, as such may often require special handling by water works management. In certain of its channels of operation, especially those for production of defense weapons, its security must be rigidly controlled. Within this expanding industry, however, many areas of operation and research require no more than the normal security controls employed in industrial practice. Water works man-

agement may be interested in the opportunities to serve the atomic energy industry, in how this service may be most effectively accomplished and in some of the benefits to both industries of a closer working relationship in water service and waste disposal.

Industrial Interest

The potential uses of atomic energy are attracting the serious attention of American industrial management. Substantial progress has been reported in gaining the interest of American industry in the present and potential uses of atomic energy (1). This interest ranges from special use of isotopes for industrial research to the evaluation of possibilities of ultimate use of this energy for production of power. Although atomic energy is currently used mainly for military weapons that require rigid security guards, it is hoped that this new source of energy will find its greatest application in helping to improve the standard of living. When this goal is achieved, atomic energy will be widely used in industry and in numerous other channels of personal and community life. Because water is an essential commodity in all of these avenues of effort, water works officials should have an understanding of this new industry and its products, procedures and problems in order to be able to help.

The electric power industry has such an obvious interest in the development of atomic energy that nearly three years ago high-level representatives of that industry recorded with the Atomic Energy Commission their desire for closer integration in the development of this new industry. The Ad Hoc Advisory Committee on Cooperation Between the Electric Power Industry and the Atomic Energy Commission was therefore appointed (1). After a careful investigation, the committee submitted, in March 1951, a very important report recommending a permanent advisory committee of the industry which would make continuing studies in areas of mutual interest (2). Continued development of the relations between these two industries is in progress.

Special Water Needs

The requirements of the atomic energy industry for water service generally parallel those of other industries, large and small, depending on their products. Some unique requirements exist, however, and should be emphasized. In some uses of water in this new industry, special refinements, which may exceed those of many other industries, are needed. Among these needs are:

1. Rigid quality standards, especially those defining permissible concentrations of certain dissolved salts
2. Low temperature and high rates of consumption of water used for heat exchange
3. Extraordinary provisions for uninterrupted water service.

It could be highly objectionable if water used for heat exchange in a water-cooled reactor contains a dissolved salt of an element that, when irradiated by neutrons, has a long half-life. Costly treatment may be required to reduce the radioactivity of such water to a level that will be safe when the water is released to a sewer, a waterway or to the ground. Water is commonly used as a shield against radioactive materials and when so used should have a high order of purity. In certain processes, completely deionized water may be required. The high temperatures from nuclear fission necessitate effective functioning of heat exchangers at all times with no possi-

bility of an interruption in service that might result in costly damage to an important facility.

For an industry producing or using atomic energy or related products, the chemical quality and adequacy of service of water supplied by a public utility would obviously determine whether that supply may be used or a special one need be developed. To date the atomic energy industry has elected to develop its own water supplies and systems, but as the use of atomic energy and nuclear products becomes accepted in existing industries and its base of application broadens, users may prefer to continue purchasing water from available public utilities. The specifications for water service in some plants will probably be such that the utility which is involved should be prepared to render more than just normal service to these installations.

Efforts of the Water Industry

Attaining knowledge of new industrial requirements and developing projects to permit meeting them will require initiative on the part of water works operators. They should, therefore, know more about nuclear energy and the activities and problems and personnel of the atomic energy industry. This information can be obtained in many ways, depending on the interest and alertness of the water utility and its employees. Among some water utilities, considerable staff effort along these lines has been made. The Chicago and Los Angeles water departments have purchased instruments for measuring radioactivity in water and are carrying on some research of their own. Other utilities have assigned qualified staff members to attend special training courses at seminars organized by the Atomic Energy Commission, the Public Health Service or certain universities. The newly authorized A.W.W.A. Committee on Instrumentation and Methods of Testing Radioactive Contamination of Water is one excellent forward step. Water-decontamination research at the Oak Ridge National Laboratory has had the benefit of the work of an advisory committee on which the water industry and public health officials are represented. Several staff representatives of water utilities, water works equipment manufacturers and water works consulting engineers have AEC security clearance and are now working on problems of the atomic energy industry. There is need and opportunity for much more participation of this kind, and the A.W.W.A. would do well to expand its efforts to integrate more closely the work of the water works and atomic energy industries.

Efforts of the AEC

The Atomic Energy Commission's policy, with due consideration for security, is to help all who are interested in the development and use of atomic energy for nondestructive purposes. The AEC made a start in this direction in January 1949, when the director of engineering invited representatives of several national organizations interested in water supply and waste disposal to attend a seminar in Washington, at which problems of waste disposal in the atomic energy industry and related subjects were discussed.

Extension of knowledge and service between representatives of any two industries is a two-way effort. Understanding of broad cooperative programs and objectives can usually be best developed in the initial phase through negotiation among top-level representatives of the industries concerned. But day-to-day, man-to-man, friendly rela-

tionships between staff experts on both sides are the most satisfactory cohesives for effective and continuing work. If the water works or any other industry has a problem or feeling of anxiety concerning any operations or expanding programs of the AEC, this situation can certainly be resolved if the facts are brought to the attention of commission. The importance of water supply and the interests of the water works industry in the atomic energy industry are well recognized.

As an aid to management, AEC operations and research are decentralized, with managers in charge of field activities and contract projects. These managers are interested in promoting good-neighbor policies, and contacts with local water utility representatives who have problems are therefore welcomed. In some areas, notably at Hanford, Wash., and Schenectady, N.Y., advisory committees have been organized to avail area officials of advice and assistance from state public health and conservation officials and also to acquaint these officials more intimately with the work of the atomic energy industry related to their fields.

Mutual Interests

Some areas of mutual interest between the water works and atomic energy industries might well include: [1] staff training; [2] development of special instruments for use in water works; [3] standards of water quality and service; [4] effect of radioactive and toxic wastes on water supply sources; [5] use of nuclear energy in research in water supply, water purification and plant operation and maintenance.

The need to train staffs in the nuclear sciences is common to most industries that will serve or be served by the atomic energy industry. The results of such a program would be in proportion to the effort and time invested. The program should be developed only after an evaluation of current and potential requirements and interests, for many sectors of the new industry would obviously not concern water works officials. Development of interindustry training programs requires no further elaboration than to mention the existence of unique and novel features in the field of nuclear sciences that may currently be unfamiliar to most water works officials. Planning and practice in these areas will require proper adjustment of perspective.

Although much development work has been undertaken in instrumentation, it will require special adaptation for use in water works research and practice. Some work along these lines has already been carried out, but much exploration, research and development must yet be undertaken. In its operations, particularly during recent years, the water industry has come to a greater appreciation of the value and economy of instrumentation. Manufacturers of facilities for this service should also be invited to participate in any cooperative program that is undertaken.

Potentialities of Atomic Energy

The use of radioisotopes and other forms of nuclear energy as tools in research, operation and maintenance of water works facilities has great possibilities. In the art of water purification, many areas of ignorance exist because of a lack of sufficiently accurate means of studying the reasons for observed phenomena. Better understanding of the nuclear sciences and the use of atomic energy would quite possibly clarify a number of unknowns. For example, how well understood are the reasons for good and poor chemical

coagulation as an aid to water purification or the factors which control settling of suspended and coagulated solids? Is the bactericidal effect of chlorine or chlorine compounds when added to water for disinfection fully explained? Are the factors which contribute to the efficiency of water filters really understood? Research with neutron sources and gamma rays in the oil industry suggests that explorations for ground water could quite possibly be simplified and made more accurate. The perennial problem of corrosion will probably be better understood through the use of radioisotopes. By using radioisotopes, the complex problem of determining flows through conduits and pipes, either in long lines or in grids, may be simplified. By using nuclear tools, more accurate records may be developed of water levels in reservoirs and their actuating devices. These are but a few examples of the possibilities for using atomic energy in the water works industry, and they tend to emphasize why the profession should be alerted to use nuclear methods as well as the more common mechanical, chemical and physical techniques.

Possible Contaminants

Water contamination is a matter of concern to all water works operators. An alert water utility management is aware of existing or potential hazards to its sources of supply wherever these hazards originate. Notification to downstream water works officials of spills of industrial wastes have been arranged in many areas, especially in the Ohio and Mississippi Valleys.

The atomic energy industry produces a wide variety of wastes, both toxic and radioactive. These contaminants have entirely different properties from those of other industries and should be understood by all those interested in or concerned with water contamination. Wastes from plants at which atomic energy materials are prepared and produced as well as those at which radioisotopes are used for research are in this category.

The AEC and its contractors have given much consideration to developing satisfactory methods of treatment, storage and disposal of wastes from this new industry (4, 5). It is doubtful if any other industry at the same level of development has carried out equally thorough research along these lines. The uniqueness of the contaminants and the lack of knowledge of their effects on living material and property have prompted this policy of prudence. Some wastes from atomic energy operations are sufficiently valuable to be reclaimed. Because decontamination facilities have not yet been installed, it is not uncommon at some production areas to store large volumes of radioactive waste products in tanks.

Waste disposal in the atomic energy industry is a relatively expensive effort as compared with disposal in other industries, but, as research progresses, such costs will probably be reduced. The current effort is to explore and develop the most promising waste-disposal methods. Advantage is also taken of natural dilution wherever possible, and increased use of this factor is being continuously evaluated.

Research Contracts

The AEC, through its contractors at plants and national laboratories and by contract with private research organizations and universities, is endeavoring to obtain information to help the water works profession in meeting problems of radioactivity contamination. The Oak Ridge National Laboratory and, by contract, the Sanitary En-

gineering Division of the Massachusetts Institute of Technology, have been conducting research in decontamination of radioactive waters by orthodox and special purification methods for more than two years (6, 7).

To assist the water works operators who depend on impounded water without subsequent purification, a research project is being financed by the commission with the School of Engineering Sciences of Harvard University to ascertain the fate of radioactive materials when introduced into open reservoirs and pipelines. To date only iodine (I^{131}) and phosphorus (P^{32}) have been experimented with, but others will be included as the research continues. Under this contract, it has been found necessary to develop some special instruments for recording radioactivity in water. As soon as this research reaches a stage at which useful information can be released, such facts will be published in an unclassified report. Other universities working on problems of disposal of liquid wastes in buildings, to estuarian waters and by established sewage treatment processes are Johns Hopkins, New York University (8) and the University of California. Research contracts of this kind with universities also have the advantage of stimulating interest of students in the work of the atomic energy industry. Such federal agencies as the U.S. Public Health Service and the U.S. Geological Survey, with which the water works industry is accustomed to work, are actively cooperating with the commission and its contractors in evaluating the relation of waste disposal and decontamination to water supply and water resources. These agencies are conducting research work in their own laboratories and have been extremely helpful in solving problems of plant site selection.

In the atomic energy industry, much attention is being given to treatment of gaseous effluents so that environmental problems, such as those experienced by other industries, may be prevented. In the development of filters for removing radioactive and toxic particulate material from gaseous effluents, development work under AEC contracts has resulted in production of very efficient facilities (9). At Harvard University (10) and the University of Illinois, studies on air-cleaning methods and equipment and basic studies on aerosols have provided notable contributions to knowledge in these fields. The U.S. Bureau of Mines (11), under an AEC contract, is developing an incinerator that will destroy combustible material contaminated by radioactivity without release of hazardous products in the gases of combustion. The U.S. Weather Bureau is cooperating actively with the commission in evaluating the meteorological aspects of the release of gaseous effluents from atomic energy operations. It is especially important that this agency with nationwide facilities for observing and studying meteorological conditions be closely integrated with the atomic energy industry, because some radioactive wastes, including those with long half-lives, can be carried in the atmosphere far from their sources of origin and can be washed out by rain and snow. The fate of radioactivity which is deposited by these and other means is being carefully investigated. The attachment of radioactivity to soils and other surfaces is not well understood but may be most fortunate for water works operation. This action is also being investigated at the Brookhaven National Laboratory and elsewhere.

Atomic weapons and their effects on water supplies and facilities present a tremendous problem. The interest and

concern of the water industry in this phase of nuclear fission is understandable. Although this article does not discuss the civilian defense aspects of water works operation, it should be noted that the commission is actively working with federal civilian defense officials to assist them in serving the industry.

Because of the wide variety of water works structures and facilities in operation, the great variations in area topography and environmental features, and the numerous possible types of explosions which may occur and their distances from key units in water system, specific advice applicable to all areas is difficult to offer. Monitoring teams working for the civilian defense agency will be prepared to evaluate types and amounts of radioactivity released under emergency conditions. In an atomic attack, every water works operator should also be prepared to do his part in civilian defense.

It may be seen that wide areas exist for cooperation between the water works and atomic energy industry. As the latter expands, except for production of weapons, private enterprise will probably use atomic energy and atomic energy products in greater amounts and with wide diversification both in industrial processes and research. Many of these users are already or will soon be customers of water utilities. The staffs of these utilities have an obligation and an opportunity to serve this new industry. Atomic energy will certainly be a powerful factor in research and plant operation and maintenance. Preparations should be made, therefore, to take full advantage of these opportunities.

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Comparison Between Synthetic and Natural Rubber Pipe-Joint Rings

By W. L. White

A paper presented on May 1, 1951, at the Annual Conference, Miami, by W. L. White, Director of Research and Product Design, The Manhattan Rubber Mfg. Div. of Raybestos-Manhattan, Inc., Passaic, N.J.

THE National Production Authority of the U.S. Department of Commerce issued an amendment to Order M-2 on March 1, 1951, prohibiting the use of natural crude rubber in the manufacture of pipe-joint rings. It may be of interest to discuss the significance of this directive and the results that may be expected from the use of pipe-joint rings made from synthetic rather than natural crude rubber.

Early Uses

The first recorded use of rubber pipe-joint rings was for a pipeline laid in England in 1863. The first practical use of such rubber rings in the United States was in a pipeline laid in Elizabeth, N.J., in 1870. In the same year, a line was laid in France. The purpose of using rubber rings in all these early lines was to provide a flexible seal that would remain tight despite the subsequent movement of pipelines because of earth settlement or contraction and expansion of the pipe.

These pioneers were well aware of the fact that the entire future of their business depended upon finding a flexible joint ring that would permit such movement of the pipelines. No such science as rubber chemistry existed, and no methods of testing quality or expected life of rubber rings were known. It had been observed that rubber possessed the natural property of flexibility and that, if it was kept in a cool, dark place, it seemed to have remarkably good aging properties. It was reasoned, therefore, that, since pipelines operated under such conditions, rubber offered a material for making successful flexible pipe-joint rings, and subsequent events justified this theory. Each of those first pipelines with rubber joint rings met the most optimistic expectations. The Elizabeth line was removed after 60 years of perfect performance and was replaced only because a larger line was needed. Good results were also recorded for the early lines laid in France and England, and it thus was proved that rubber rings would function for the life of the pipeline, making possible the vast network of pipelines that now serve the needs of modern civilization.

Studies

In the years that followed these first experienced. Not all types of rubber were found to be equally useful for pipe-joint manufacture. The pipe and coupling manufacturers instituted a study of joint and coupling design. The rubber manufacturers made studies of rubber compounding. The pipe and coupling manufacturers in cooperation with the rubber-ring manufacturers experimented with various types

of rubber compounds, shapes and sizes of rings and methods of confining these rings to give best results. Test lines were set up duplicating every possible condition under which the pipelines would operate in actual service, and these test lines were made to function under conditions which were much more severe than those of normal operation, thus developing accelerated tests. Through these combined efforts, specifications and rigid controls were finally drawn up to cover both the manufacture of pipe and couplings and the qualifications of the rubber rings necessary to assure continued reliable, dependable service operation. The program of test and development has never been stopped and probably never will be. Each year additional improvements are made.

Properly designed rubber rings are now used almost universally on cast-iron, steel, concrete, prestressed concrete and asbestos-cement pipelines. The manufacturers of these pipe-joint rings have invested much time and care in developing these rubber rings. They have a full realization of the importance of their product in the water works industry. Only after careful testing and consideration is synthetic rather than natural crude rubber now being used in the fabrication of the rings.

Importance of Synthetic Rubber

Natural crude rubber is so versatile in its properties and uses that it has found an essential place in every great industry. During World War I, the Allied blockade that eventually proved fatal for Germany cut her off from most of her imports. She discovered early that the most essential of all imports was crude rubber. Every effort was exerted to produce a synthetic rubber, and a small quantity of a very inferior grade was produced. Germans claimed that the lack of crude rubber was more responsible for their defeat than any other single factor. In the early 1920's Germany began to prepare for another war, and high on the priority list was the development of a synthetic rubber to replace natural crude rubber.

The United States was also interested in synthetic rubber, but for an entirely different reason. Natural rubber can be compounded and used in many and widely different types of vital necessities, but it does have one deficiency—it is not impervious to oils and solvents despite the best efforts of the rubber chemists to make it so. Because oil-resistance was demanded it was necessary to develop an oil-resistant, rubber-like synthetic product.

Many synthetic rubbers were produced. Some showed promise of oil-resistance; those that did not were discarded. The quest was for an oil-resistant, synthetic product to supplement, but not necessarily replace natural crude rubber. From all this research came the Thiokols,* Neoprenes,† acrylonitrile rubbers and others.

After fifteen years or more of intensive work, implemented by government funds, the Germans developed their Buna synthetic rubber to production scale in 1936. In that year, the author visited Germany to investigate the mechanical difficulties and successes experienced in making useful products of these rubber-like synthetics. The German government not only financed this development but, through its controls, forced manufacturers to use these products regardless of extra costs or difficulties in operation. American research men received no such political subsidi-

* A product of Thiokol Corp., Trenton, N.J.

† A product of E. I. duPont de Nemours and Co., Wilmington, Del.

zation. World War II broke out only after Germany felt she was prepared either to prevent a blockade, or to produce synthetically for all needs from materials available within the Reich.

As a result of the German's own submarine blockade, thousands of tons of shipping were sunk in American harbors, and this country also learned to know the havoc that could be wrought on its economy. At the start of the war, the United States had a total supply of 500,000 tons of crude rubber with an annual domestic consumption of 700,000 tons. The tremendous war effort would obviously consume a great deal more than this amount.

The Baruch Report

The Baruch committee on September 10, 1942, reported:

> Of all critical and strategic materials, rubber is the one which presents the greatest threat to the safety of our Nation and the success of the Allied cause. Production of steel, copper, aluminum alloys or aviation gas may be inadequate to prosecute the war as rapidly and effectively as we could wish, but at the worst we are still assured of sufficient supplies of these items to operate our armed forces on a very powerful scale, but if we fail to secure quickly a large new rubber supply, our war effort and our domestic economy both will collapse. Thus, the rubber situation gives us our most critical situation.

William M. Jeffers was appointed Rubber Director. His efforts were concentrated in two great channels. Conserving the rapidly diminishing rubber stockpile was the first of these. The manufacture of all nonessential rubber products was prohibited. The proportion of crude rubber in essential products was repeatedly reduced. Reclaimed rubber was used to replace part or all of the crude rubber. The water industry also played a part in this conservation effort. In January 1944 the national stockpile was reduced to 20,000 tons below Baruch's recommended safe limit. The total collapse of the domestic economy and war effort that Baruch warned against two years before was less than a few months away.

The second great effort of the Rubber Director was to provide for synthetic rubber production. A small group of rubber research chemists, chemical engineers and design engineers was recruited from the staffs of the large rubber companies, oil and chemical companies and large industrial engineering organizations. They were given perhaps the most important assignment ever entrusted to such a small group of men in the history of the country. The destiny of the United States and the fate of the Allied efforts depended upon their success. They had to accomplish their purpose within two years as the stockpile could not possibly last longer. They had to select the types of synthetic rubber to be made, design equipment for its production, build and fabricate this equipment, select manufacturing sites, erect buildings, assemble operating crews and train them for the specialized work. They were faced with the problem of providing a quantity of synthetic rubber equal to the total prewar annual use of natural rubber.

Such production would normally start in research laboratories, proceed through pilot plant development and finally go slowly into production, but there was no time for such orderly development. One jump from test tube to full production was needed. To paraphrase Winston Churchill, never in history did the fate of so many people rest in the hands of so few. There was assembled $760,000,000 worth of buildings and equipment; a most difficult and intricate chemical problem was solved;

crews of men were trained and made specialists; and, by midsummer of 1944, synthetic rubber began to stream forth in ever-increasing flow, bringing new life and new hope to a nation that was engaged in the greatest mechanical war ever known.

Work of the Ring Manufacturers

As synthetic rubbers became available, the rubber ring manufacturers began their intensive investigation and development work. The effects of accelerators, plasticizers, reinforcing pigments and other such items had to be determined. No new equipment was found to be needed to process these synthetic rubbers. No substantial changes needed to be made in mold design. All the methods for testing of natural rubber were applicable with little or no modification. Then began the specific test of synthetic pipe rings using all the accelerated tests that had been used for rubber rings. Test after test was most favorable. Synthetic rings were generally the equal of prewar rubber rings in all respects and considerably better than the mixture of reclaimed rubber and natural rubber used in the 1943–44 conservation period. In 1945 synthetic rings went into production.

Only a few minor failures of these synthetic rings were reported, and every investigation indicated that the rings which had failed were not the synthetic rubber ones, but those made of a mixture of new and reclaimed rubber during 1943–44, or were the results of obvious mechanical difficulties.

Postwar Errors

Immediately after V–J Day rapid demobilization of the armed forces started. The Navy was quickly decommissioned, and hurried liquidation of war surplus materials was instituted. Today's international situation indicates that less haste would have been much wiser. When crude rubber was again available, lifesaving GR–S * was forsaken and natural rubber returned to use. Some of the manufacturers were quite as guilty as the consumers.

Wartime problems of depleted operating staffs which were often replaced with inexperienced and inapt personnel were soon forgotten. Synthetic rubber became the whipping post for all wartime sins of commission and omission and a general rush back to crude rubber ensued. Everyone felt that all the troubles would be over and the crude rubber rings of the "good old days" would again be plentiful. But upon returning to this "Promised Land," some of the troubles that had been overlooked were recalled. Crude rubber lacks uniformity of grade. There are 24 recognized grades of crude rubber, each of which overlaps the next. Even within a single grade, two lots from different plantations and locations may show quite marked differences in curing rate, plasticity and other properties.

The rubber plantations themselves had also had war troubles. Their organizations had been depleted or disbanded. Former channels of collection and distribution no longer existed. The only way to secure uniform products was to undertake an extensive blending operation, and even then constant difficulty was encountered in producing rubber rings that were identical with prewar standards. It soon became apparent that it might have been a mistake to discontinue use of synthetic rubber so quickly. The manufacture of synthetic rubber, while materially reduced, was, of course never entirely discontinued. Research work

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* U.S. Government designation for styrene synthetic rubber, derived from: Government Rubber—Styrene.

was continued, and many technicians were even convinced that the synthetic rubbers were not merely war products but also had peacetime usefulness. Research men continued their work, not merely refining their products and processes, but investigating some of the optimistic techniques they had been forced to bypass during the war rush. Manufacturers of carbon black, plasticizers, accelerators and other such items which were used with these synthetic rubbers also continued research work. All of this work was very worthwhile. An example of its value is the development of so-called "cold GR–S," from which tire manufacturers claim even better wear and longer life in tire treads than the best crude natural rubber. Test comparisons of conveyor belts, hose, roll covers and other such items show similarly good results. Before 1952, half of all GR–S production will be converted to this improved cold rubber.

Synthetic Rubber Rings

Pipe rings of synthetic rubber which will show more uniform resistance to compression and will flow less under compression than the best rings ever made of natural crude rubber can now be made. Resistance to aging is better. Uniform high quality is more easily controlled. Some types of synthetic rings will meet the same specifications used with natural crude rubber. For other rings, the specifications will be changed slightly, but these changes are merely a reflection of the inherent physical properties of the rubber polymers and do not necessarily have any relationship to the test performance of the rings in the pipelines. In every one of the accelerated-service type tests developed throughout the years, synthetic rings have been shown to perform equally as well as or sometimes better than the best natural crude rubber rings—either postwar or prewar. Good synthetic rubber rings were made in 1945, and the author has not yet found a line failure due to the use of synthetic rubber in these rings. Better synthetic rings are now made than were fabricated in 1945. Tomorrow and a year from tomorrow, still better synthetic rings will certainly be manufactured.

Any synthetic rubber ring put in any joint or coupling will not necessarily be satisfactory. No easy, cheap substitution exists for good engineering, good design, good workmanship and a proper realization and knowledge of the type of service the rings must supply in the joints of a pipeline. The same forces that in 1944 wrought the miracle of synthetic rubber production can and will continue to develop and improve it. The rubber ring manufacturers who developed the necessary and vital qualifications needed for natural-rubber pipe-joint rings have the ability, desire and incentive to make equally good or better rings of synthetic rubber. Unless unreasoning mob hysteria again clouds engineers' and manufacturers' reasoning, man-made synthetic rubber is here to stay in pipe rings. The future will probably show that better rings can and will be made of synthetic rubber than probably ever could or would be developed from natural crude rubber, which varies with every whim of nature and is always influenced in production by the changing political situations that apply to the nations that produce it.

No apology is necessary for the use of synthetic rubber rings. They can be bought, sold and used with every assurance if one deals with those who are experienced in the art, know the importance of the mechanics of the joint and have shown from past performance that they are worthy of respect and confidence.

Fluctuations in Water Use and Revenue

Panel Discussion

A panel discussion presented on May 3, 1951, at the Annual Conference, Miami.

Richard E. Bonyun

Gen. Supt. and Chief Engr., Passaic Valley Water Commission, Clifton, N.J.

FLUCTUATIONS in water consumption are experienced in all water supply systems, and they are reflected by variations in the revenues received.

The Passaic Valley Water Commission owns and operates the water supply and distribution system for Paterson, Passaic and Clifton, N.J., and supplies water at wholesale rates to many surrounding municipalities and water companies. The system is located in the northern New Jersey metropolitan district, approximately sixteen miles from New York and serves a highly industrialized section of the state that has a population of approximately 350,000. The average water consumption is approximately 65 mgd.

Factors Governing Survey

Several factors, of course, are involved in such a study, but the principal ones are the type of water load carried and the water rates charged which produce the revenue.

These factors are important in an investigation for the following reasons:

1. The heavy industrial load which is supplied is subject to great fluctuations during the year.

2. The rates are perhaps unusual as the sliding scale embraces such a wide range. The rate starts at $1.25 per 1,000 cu.ft. and gradually decreases to $0.45 per 1,000 cu.ft. with greater consumption.

The year 1950 has been used as a basis for this analysis. Figure 1 shows water consumption for the year. The consumption load has been broken down into three categories: [1] domestic and commercial, [2] wholesale, and [3] industrial.

Variations in Supply

In Fig. 1 the amounts of metered water in the three categories have been plotted by months and added to each other so that the top line indicates total consumption. Seasonal variations in the domestic load are included. The wholesale demand also varies but is influenced by the industrial load in the cities so supplied at wholesale. The top block on Fig. 1 represents industrial consumption in the retail district of Paterson, Passaic and Clifton and shows the wide variations in this load. The large decrease in July is the result of the annual vacation shutdown of the mills served by the system, a great many of which shut down simultaneously for a two-week vacation period at the beginning of that month.

Rates

The commission's retail and wholesale rates are shown in Fig. 2. The retail rate has a very wide range, starting at approximately $170 per mil.gal. and sliding down to $55 per mil.gal. for the large consumer. This rate applies to all retail consumers—both domestic and industrial—but of course favors the large consumer. The wholesale rate is a flat rate and is approximately $82 per mil.gal. for all users.

Revenues

The revenues from the three service categories have been plotted in Fig. 3.

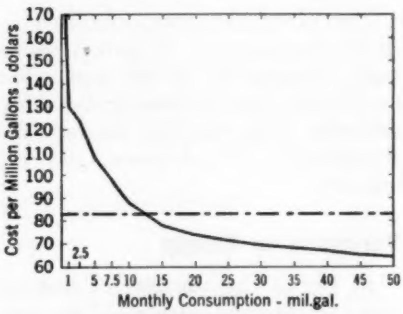

Fig. 1. Consumption

Water supplied by the Passaic Valley Water Commission during 1950 are broken down into industrial, wholesale, and domestic and commercial categories.

The block for each category is placed on top of the preceding block as in plotting consumption. The top line of Fig. 3 represents the total revenue derived from the three types of service. The tempering effect of the sliding scale of retail rates is clearly indicated. Industrial consumption in July dropped 23 per cent below the mean, although the revenue in this block decreased only 16 per cent, which indicates that the decrease in consumption was for low-priced water. Conversely, in August, use of industrial water increased 41 per cent above the mean, but the revenue increased only 25 per cent.

Domestic and commercial sales constitute the most solid part of the commission's revenue. This water is relatively high priced and is subject only to minor seasonal variations. Domestic

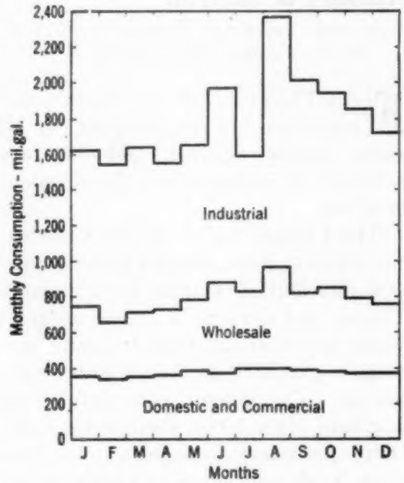

Fig. 2. Retail and Wholesale Rates

Retail rates charged by the Passaic Valley Water Commission are represented by the solid line, and wholesale rates are represented by the broken line.

and commercial consumption represents only 21 per cent of the total water, but the revenue produced by this block is 41.5 per cent of the total. The other two categories are wholesale water, representing 24 per cent of total and 16 per cent of the revenue, and industrial water, representing 55 per cent of total and 42.5 per cent of revenue.

During the month of July, when the sharp drop-off in industrial sales oc-

curs, domestic consumption is fortunately at its maximum tending to maintain even revenue distribution. Commercial and domestic use compensate for changes in the wholesale load.

The effect of these relationships on total revenue is shown in Fig. 3 on the upper line, which is remarkably level considering the great fluctuations which occur in the industrial load. When

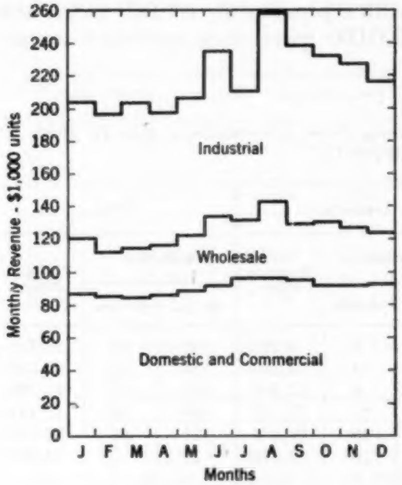

Fig. 3. Revenues

Total 1950 revenue of the Passaic Valley Water Commission is broken down into industrial, wholesale, and domestic and commercial categories.

the total consumption was 11 per cent below the mean in July, the total revenue was reduced only 4 per cent.

The commission's water-rate schedule therefore seems well designed and meets the needs of the system. The sliding scale of retail rates is very attractive to industry which the cities are most anxious to serve, and it has the definite advantage of maintaining an evenly distributed revenue.

W. H. Boquist

Comptroller, Hackensack Water Co., Weehawken, N.J.

The Hackensack Water Co. supplies water to 53 municipalities in northern Hudson and Bergen Counties in northeastern New Jersey close to metropolitan New York. The territory covers a generally rectangular area approximately 7½ miles wide and 18 miles long, and consists of two longitudinal valleys and separating ridges with elevations from 0 to 500 ft. above mean sea level.

The source of supply is the Hackensack River and the Pascack Brook, which, with their tributaries, have a drainage or watershed area of 116 square miles. Water from these streams is impounded in two storage reservoirs, Woodcliff and Oradell Lakes which have a combined capacity of almost 4 bil.gal.

In 1949 45.085 mgd. were pumped into the distribution system. The system is completely metered and had 100,289 accounts at the end of December 1950.

Rainfall deficiency in the area from June 1, 1949, to December 31, 1949, was 9.17 in. During this period, the rainfall was 16.66 in., or approximately 64 per cent of normal (25.83 in.). Continued dry weather during the fall and early winter of 1949 had considerably depleted the impounding reservoirs of the company by the end of the year. The company therefore solicited the cooperation of its customers in conserving water.

The conservation campaign effected an immediate reduction in consumption. For the last half of December, 1949, when the campaign was begun, there was a reduction of approximately 19 per cent in daily average use.

Table 1 shows the consumption decrease and the revenue loss for the period until May 1950 compared with the same months of the previous year.

The reductions were the direct result of the exercise of care in drawing water by the customers' repairing defective fixtures, substituting other sources of supply, such as wells, as was done by several car-washing establishments, and curtailing of use by industries. One large consumer, who previously used a considerable amount of water for cooling purposes, adopted a maintenance plan involving the adjustment of certain valves to reduce the water flow while maintaining proper operation. This saving, plus other waste elimination at this one plant, reduced its consumption by 375,000 gpd. or 42 per cent.

The conservation program made customers so waste-conscious that the momentum gained required some time to dissipate.

In February 1950 customers were informed that the company's reservoirs again contained normal operating levels and, therefore, strict conservation was no longer necessary. Because the emergency period only lasted approximately two months, it seemed logical to assume that consumption would quickly revert to normal volume. In spite of official discontinuance of the conservation program, however, consumption continued to decrease for many months.

When considering a water system with approximately 100,000 meters and 500,000 users, it is reasonable to assume that educating the public to avoid waste will have some lasting effect, and therefore, some, although perhaps only a small proportion, of the company's revenue will not be recovered.

TABLE 1

*Estimated Reductions in Consumption and Revenue From Conservation to May 31, 1950 for Hackensack Water Co.**

Month	Industrial			Domestic			Total		
	Reduction		Revenue *dollars*	Reduction		Revenue *dollars*	Reduction		Revenue *dollars*
	mil.gal.	*per cent*		*mil.gal.*	*per cent*		*mil.gal.*	*per cent*	
Dec. 1949†	90	17	20,520	11	2	3,245	101	19	23,765
Jan. 1950	160	30	36,480	28	4	8,260	188	16	44,740
Feb. 1950	132	30	30,096	60	9	17,700	192	17	47,796
Mar. 1950	111	21	25,308	58	11	17,110	169	16	42,418
Apr. 1950	59	13	13,452	66	10	19,470	125	11	32,922
May 1950	11	2	2,508	66	10	19,470	77	7	21,978
TOTALS	563		128,364	289		85,255	852		213,619

* Revenue figures do not include flat rate charges.
† One-half month.

Table 2 compares the revenue loss from consumption charges to metered customers for the months during conservation with the revenue increase from consumption charges for the same months after the emergency period. The 1951 increases represent the recovery of conservation losses and additional sales to new customers. Dur-

ing 1950 a total of 5,666 new customers were added to the system.

A review of the figures covering metered consumptions in Table 1 indicates that industrial consumers showed a greater reduction than domestic customers, although the revenue losses for industry were recovered more quickly.

In addition to the $213,619 loss to May 1950, further losses should be chargeable during the ensuing months as a result of this program. These figures cannot, however, be easily or correctly determined because of variable factors such as summer loads, weather conditions and additional customers. A reasonable estimate of the loss for these additional months might be $40,000–$50,000. The conservation program implemented by the company as a result of the 1949 drought is estimated to have caused a revenue loss of at least $250,000, which represents approximately 5 per cent of the total revenue for 1950.

TABLE 2

*Monthly Revenue Losses and Increases for Periods During and After Conservation**

Month	Monthly Revenue Losses—*dollars*		
	Industrial	Domestic	Total
1950			
Jan.	36,480	8,260	44,740
Feb.	30,096	17,700	47,796
Mar.	25,308	17,110	42,418
TOTAL	91,884	43,070	134,954
	Monthly Revenue Increases—*dollars*		
1951			
Jan.	42,826	8,413	51,239
Feb.	32,248	15,216	47,464
Mar.	26,522	19,190	45,712
TOTAL	101,596	42,819	144,415

* First quarter of 1950 represents conservation period; first quarter 1951, postconservation period.

W. G. Banks

Div. Engr., Div. of Water, Dept. of Public Works, Newark, N.J.

Water works operators in northeastern New Jersey, the metropolitan New York area and New York City were confronted with a serious water shortage during the last quarter of 1949. Exceptionally little rainfall and the large consumption in the area were the two factors creating this condition. During October 1949, the operators of the large systems met frequently to discuss the situation and methods of avoiding a more serious shortage. Because a water shortage in an area serving a population of 3,250,000 would be catastrophic, the group decided to institute a conservation program to reduce water consumption in every way possible. Publicity was given to the situation during the latter part of October and was intensified during November and December 1949 and January and February 1950.

TABLE 1

Relationships Between Consumption and Revenue

Year	Consumption—*mil. gal.*		Revenue—*dollars*	
	Annual	Daily	Annual	Per Mil. Gal.
1948	31,830.1	87.0	3,617,184.20	113.60
1949	30,731.6	84.2	3,532,002.13	115.00
1950	27,767.1	76.1	3,363,029.51	121.30

Results of Conservation Program

Public response from November 1949 until June 1950—when the rainfall became normal or more—was excellent. Newark, N.J., which serves water, to Belleville, and Bloomfield and Elizabeth in addition to its own population,

consumed approximately 84.7 mgd. in November 1948. In November 1949, the daily consumption dropped to 80.3 mgd.—a decrease of 5.2 per cent. Average consumption for December 1948 was 85.3 mgd., whereas it dropped to 70.1 mgd. in December 1949—a decrease of 17.8 per cent. For January 1949 it was 82.4 mgd. but only 67.0 mgd. in January 1950—a reduction of 18.7 per cent. Average consumption for the three months of February, March and April 1949 was 82.4 mgd. and for the corresponding three months of 1950 was 69.1 mgd.—16.1 per cent less. The conservation program for Newark and the municipalities served, for the period November 1, 1949, to June 1, 1950, effected a reduction of 13.1 mgd.—a decrease of 15.6 per cent when compared with the corresponding period for the previous year. For the calendar year of 1950, a total reduction of 2,964.6 mil.gal. less consumption than in 1949 was realized—a decrease of 9.6 per cent. After the program was intensified in December 1949 and January 1950, there was a considerable decrease in the consumption, showing the effectiveness of the program and customer cooperation.

After improved rainfall permitted the relaxation of the conservation efforts during May 1950, there was a complete recovery and continuation of normal consumption. This increase for the period from November 1, 1949, to March 31, 1950, amounted to 11.6 per cent more than the corresponding period a year later.

A corresponding decrease in revenue as a result of the decrease in consumption did not result. Net sales from January 1 to June 30, 1949, were $1,578,423.39; from January 1 to June 30, 1950, they were $1,455,824.49—a decrease of 7.8 per cent. During this same period, water consumption decreased 17.1 per cent. This relationship indicates that a considerable amount of the saving was in nonrevenue-producing water: leakage, waste from mains, hydrants and services and from house fixtures not registered on meters. This indication is somewhat confirmed by Table 1.

Technical Practices in Cathodic Protection

Correlating Committee on Cathodic Protection

This is Bulletin No. 3, latest of a series prepared by the Correlating Committee on Cathodic Protection, H. H. Anderson, Chairman. Bulletin No. 1, containing management information on "Cathodic Protection of Buried Metallic Structures Against Corrosion," was published in the May 1948 Journal (Vol. 40, p. 485); Bulletin No. 2, "Cathodic Protection Notification Procedures," and Bulletin No. 4, "Joint Cathodic Protection Systems," were published in the September 1949 Journal (Vol. 41, pp. 845, 852).

CORROSION of metal is an electrochemical action. If metals are in contact with an electrolyte, they will corrode when electric current * flows from them into the electrolyte. Conversely, they will not corrode if the current flow is stopped or reversed in direction. A metallic structure in contact with soil is such a metal in an electrolyte. If a stray electric current flows from the structure into the soil, the metal will corrode by electrolytic action called electrolysis. If the metal is corroded by concentration-cell action —selective chemical attack on a single metal structure contacting nonhomogeneous soil—this action will generate a current that will flow from portions of the structure into the soil. This latter action occurs to some extent along all buried structures traversing adjacent soil beds of different chemical properties.

In either type of corrosion, the outward flow of current from metal into soil indicates that the metal surface is discharging positive ions and is therefore anodic. Experience proves that the attendant corrosion, if electrolytic, can be mitigated or stopped most practicably by channeling the return of current from the structure through metallic conductors leading toward the current source. If the corrosion is of the concentration cell type, or due to any causes other than stray currents, it can be stopped or mitigated by: [1] stopping the flow of current by completely insulating or coating the structure, or [2] reversing the direction of current flow to make the structure cathodic. This latter technique is called cathodic protection.

This bulletin describes briefly the fundamentals of the application of such cathodic protection, and the mitigation of any electrolytic corrosion that may be caused by stray current from cathodic protection systems. It is not intended to deal with the mitigation of electrolysis caused by stray currents from other sources.

In metropolitan areas where congested interlacings of various types of buried-structure systems exist, the problems of the mitigation of both types of corrosion are too complex to be dealt with in a bulletin of this gen-

* The currents dealt with in this bulletin are direct, or unidirectional.

eral nature. The solution of such problems is best handled by local electrolysis committees composed of engineers who represent the owners of several of the structures concerned.

Cathodic protection of underground metal structures has been used for more than twenty years, and it is of proved merit, but the methods followed in its application are still being developed, and practice by individual engineers differs in detail. Extensive correlations of experience aimed to harmonize such differences are being actively undertaken by the Technical Practices Committees of the National Association of Corrosion Engineers, and significant results should attend this work. This bulletin is confined to a general presentation of technical practices now in use.

In the application of cathodic protection, the following questions arise:

1. How much protective current is required?
2. Where should the current supply points be located?
3. What type of power supply is best suited to the particular job?
4. What kind of ground bed should be used?
5. Are the protective currents likely to stray to other structures and cause interference, or electrolysis? If so, what is the best general solution to the problem?

The answers to these questions are dealt with in the following sections.

Current Required

Cathodic protection of a buried metal structure against corrosion consists of forcing protective currents through the surrounding electrolyte, usually soil or water, into the structure to be protected in sufficient density to counteract and prevent any outward flow from the structure of stray currents or the natural currents which are always associated with the corrosion process. These applied protective countercurrents serve to maintain the surface of the structure in a cathodic state. To determine how much protective current is required for full protection, it would appear logical first to measure the densities of existing corrosion currents, and then to estimate the density of the protective current necessary to suppress them. Such direct measurement of the corrosion currents, however, is impracticable. The locations of corrosive spots are never accurately known in advance, and, even if they were, the work required to measure their individual currents would be prohibitive. Also, the first application of protective currents will alter local conditions so that the current density required initially to stop corrosion may be greater than that required later to maintain effective protection.

As a result of these conditions, corrosion engineers have developed more practical test methods and criteria aiming at:

1. A minimum of field testing consistent with reliability
2. Suitable and adequate field testing equipment
3. Test data that can be readily interpreted in terms of protection.

Most engineers agree that the most practical method of determining protective current requirements is to apply such current to the structure on a trial basis, using portable power supplies and temporarily installed anodes. The current flow can be adjusted until relatively simple field measurements indicate that cathodic protection has been established on the structure sufficient to prevent further corrosion.

The adequacy of protection is best determined by measuring the potential established between the structure and

the soil under various rates of current flow. Such potentials can be measured with a voltmeter or potentiometer equipped with insulated lead wires, one attached to a soil-contact reference electrode (or half-cell) and the other to suitable test leads or a sharp prod capable of making good electrical contact with the metallic structure. A good contact is especially important because many erroneous or misleading voltmeter readings may occur if an IR drop or a galvanic voltage is caused by any mill scale, corrosion products or pipe coating that may remain between the contact prod and the bare metal of the structure. Care must be taken not to puncture soft metals when they are being prodded.

The voltmeter should have an internal resistance at least 50 times that of the remainder of the circuit, to reduce circuit resistance errors to a practical degree. Some engineers prefer to use potentiometers because of their infinite resistance characteristics and reliability. For making the voltmeter contact to the soil, a suitable nonpolarizing reference electrode (or half-cell) is used. For testing on steel or black iron structures, a copper-sulfate half-cell is generally used. For testing on lead cable sheaths, a lead-chloride half-cell may be used. Some cable engineers, however, prefer to use an electrode made of the same metal as the structure.

The structure-to-soil potentials thus indicated by the voltmeter will differ according to the condition of the structure under test and the location and type of reference electrode used. Potentials measured with one type of electrode, however, can be expressed in terms of others by merely adding or subtracting known conversion factors. If the electrode used is reliable, its type has little bearing on the final answer. The half-cell electrodes are generally preferred because their potentials are more easily reproduced and are less affected by environmental factors.

Based on such measurements of potential, certain widely accepted practical criteria, indexes or yardsticks of adequate cathodic protection have been developed. Using the half-cell reference electrodes, experience has shown that adequate protection of steel or black-iron pipe is usually obtained if its potential is reduced by the protective current to approximately − 0.85 v. with respect to a copper-sulfate half-cell in contact with the soil.* For galvanized pipe, a potential with respect to a copper-sulfate half-cell of approximately − 1.10 v. is required for protection. Adequate protection of lead cable sheath usually is obtained if its potential is reduced by the protective current to approximately − 0.05 with respect to a lead-chloride half-cell.

Discretion must be exercised in employing any general purpose yardstick, as higher potentials may be required in such environments as cinder fills where bacterial corrosion is present. Only further testing or experience can indicate when protection is obtained under such conditions. Caution must be ex-

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* Calculated counterpotentials required to stop corrosion of iron in several different common chemical solutions average 0.283 v., and range from 0.272 to 0.291 v. Laboratory tests have produced close agreement with these figures. The potential between iron or low carbon steel (0.15 carbon content or less) in a solution and a copper sulfate half-cell in contact with this solution has been determined to be 0.54 v. Thus the potentials required between these metals and the half-cell to secure protection equal to or exceeding the calculated protective voltage plus the half-cell voltage range from 0.812–0.831. A minimum potential of 0.85 v., which allows a factor of safety, is commonly accepted as sufficient to protect most iron or steel structures underground.

ercised when applying the higher criteria for steel and black iron structures in the vicinity of other underground metal structures—particularly in congested metropolitan areas.

Using a reference electrode made of the same material as the structure is not normal practice for tests on steel or black-iron structures. The use of such electrodes is not recommended because polarization and local oxidation can introduce errors that are difficult to detect, especially if the operator is unaccustomed to their use. Underground cable engineers, on the other hand, usually prefer to use a piece of lead cable sheath for the reference electrode. Lead cable sheaths are considered to be protected if their indicated potential to soil with such an electrode is slightly negative.

Protective current flowing from the soil to a structure causes potential gradients which depend on electrode location, soil resistance and amount of current flow. The reference electrode used for measurements along a well coated pipeline or cable can be located either above or near the structure without introducing appreciable error. For measurements along a poorly coated or bare structure, some engineers prefer to locate the electrode a distance from the structure equal to the depth that the structure is buried. Others favor placing the electrode at the distance beyond which further removal causes no change in potential readings. The positioning of such electrodes is best determined by experience and will generally vary with the types of climate and soils. A special method, called the "null method," has been devised which aims to minimize the errors in electrode positioning. Engineers seeking to use this alternative method will find it explained in corrosion literature (1).

A completely different method sometimes used is the calculation of the amount of protective current required to establish a minimum adequate current density throughout the entire structure. The density required for protection of steel or black-iron structures in soils varies widely and is affected by soil type, resistivity, moisture, aeration and other such conditions. Densities considered adequate for protection of these structures range from 0.50 to 20.0 ma. per square foot depending on whether the soil is mildly or highly corrosive (2, 3). Such calculations sometimes are used to check the results obtained by the potential test methods described above. They may also be used for estimating the size of power supply required for the potential test methods.

All of the above indexes are used to determine when sufficient current has been applied. Use of larger-than-necessary currents, however, adversely affects the economy of an installation. Such a practice increases the initial cost of power-supply equipment and anodes or ground beds, as well as the annual costs of current and of anode replacements. It also increases any undesirable effects the currents may have on neighboring structures (4).

In using any of these indexes of current adequacy, it must be borne in mind that they apply only to conditions desired on the structure to be protected. The satisfactory protection of one structure may, in fact, definitely harm adjacent ones, particularly lead cable sheaths that are adjacent to steel pipelines.

Location of Current Supply Points

The locations at which protective current should be applied to a structure, as well as the amount of current required, may be determined by use of

portable power supplies connected between the structure and temporary anodes. Batteries or portable motor-generator sets can be used. The resistance to soil of temporarily installed anodes is usually quite high, so a relatively high voltage must be used to obtain currents large enough to produce reliable structure-to-soil potential readings. These readings should be taken along the structure at points progressively further from the power supply connection to insure adequate but not excessive current and to produce the desired minimum potential or potential change all along the structure.

If a long line is to be protected, the data obtained from a single temporary power supply and anode may be used to estimate the effects of additional current sources at regular intervals along the line. In such estimations, it is assumed that the change in the structure-to-soil potential produced by the test current is directly proportional to it. This assumption is not always well founded, however, because the current collected per square foot of area is not directly proportional to the structure-to-earth potential. The continued passage of current to the structure also increases its surface polarization and acts to extend the effectively protected area of the particular structure.

Depending on conditions, it may take only minutes, or it may take several weeks, for structure-to-soil potentials to become stable. Short-time tests are liable to indicate excessive current needs, and this factor must be taken into account in the final system design—largely on the basis of experience. Temporary equipment can sometimes be left in operation long enough to establish stable conditions and thus most accurately indicate the required current.

The choice of current supply locations depends largely on the type of permanent power supply suited to the job. If a central station power source is to be used, sacrifice of some engineering nicety may be necessary to reduce the cost of service line extensions. Local soil conditions also may influence the choice. A low-resistance ground reduces the voltage required to circulate the protective current and correspondingly reduces costs of installed equipment as well as the recurring power bills. It is therefore important to provide suitable low-resistance ground beds. Earth with a low resistivity usually serves best for this purpose. The fact that some locations along a structure offer better grounds than others should be coordinated with other factors.

The locations of supply points affect the tendency of cathodic current to stray into nearby structures. It is obviously desirable to select locations with the idea of minimizing adverse effects that may not be confined to electrolysis. Care should be taken to avoid locations near railroad tracks employing signal systems that might be falsely operated by direct current entering the rails. The likelihood of adverse effects should be determined by tests made in cooperation with the engineers of the railroad or other structures involved.

Available Current Sources

Sources of direct-current power considered most practical for cathodic protection are:

1. External power sources:

a. Rectifiers (a-c.–d-c.)

b. Generators driven by various types of prime movers (d-c.)

2. Galvanic anodes (magnesium, zinc, aluminum).

If large amounts of current per loca-

tion are required, it is generally more economical to use external power sources, although the use of a large group of galvanic anodes may sometimes be preferable.

Service from a-c. power, if available, is preferred as a prime source by most engineers. Some private power lines have been built adjacent to a pipeline for the sole purpose of supplying a number of a-c.–d-c. rectifiers. Most of the rectifiers in use are of the copper-oxide or selenium types, connected to 60-cycle a-c. power lines. Copper-oxide and selenium rectifiers differ in their characteristics, but both types are satisfactory for cathodic protection service. Both provide an efficient, low-cost and low-maintenance source of direct current. Comparatively few vacuum-tube rectifiers are in use, probably because they become efficient only at unnecessarily high output voltages and their current output is smaller than that for the copper-oxide or selenium types of comparable dimensions. If an a-c. power supply is available, rectifiers are much more satisfactory than a-c.–d-c. motor-generator sets.

If substantial current is required and an a-c. supply is not economically available, engine-driven generator sets may be used. Wind-driven generators, being dependent upon the weather, have only a limited field of use, but their lack of reliability can be somewhat compensated for by the addition of storage batteries or galvanic anodes. A few successful installations of this kind are in operation.

Galvanic anodes are unique because they are self-powered. Together with the structure and the soil, they create gigantic dry cells. They can efficiently produce only a few hundred milliamperes per anode, but on coated structures or on plant of limited extent, this current may provide adequate protection. It is often practical to install galvanic anodes, singly or in groups, at frequent intervals along a long line, and thus obtain the protection that might be afforded by rectifier type supplies at wider spacings. For galvanic anodes, magnesium and zinc are now favored by corrosion engineers. A new type of magnesium ribbon can be laid parallel to the line and thereby provide a continuously distributed anode. Aluminum has not yet been used extensively or shown to be suitable for this work. The characteristics of all three types are being studied by a committee of the National Association of Corrosion Engineers (5).

The most appropriate metal for and disposition of galvanic anodes for protection will depend upon the metal of the structure and the soil conditions. Other conditions being identical, the current output of a galvanic anode depends on the effective electromotive potential of the anode metal relative to that of the structure metal.

Open-circuit potentials between properly installed galvanic anodes and reference half-cells in contact with adjacent soil are relatively constant. The potential of magnesium relative to copper sulfate is approximately 1.5 v. and that of zinc to the same reference approximately 1 v. It is often impossible, however, to predict accurately the effective potential of a galvanic anode relative to an undisturbed buried structure for two reasons: [1] The theoretical relative potentials calculated from the values listed in electromotive series tables of handbooks are seldom realized when the two metals are placed in soil or water. [2] The innumerable and often wide variations of undisturbed structure surface and burial environment cause corresponding and unpre-

dictable effects on these potentials. Only local experience or testing can, therefore, determine with reasonable accuracy what effective open circuit anode-to-structure potential may be realized in a particular installation.

Anodes and Ground-Beds

The design of a good ground for the current supply depends on soil conditions and the amount of protective current required (6). The term "ground bed" usually refers to a group of anodes interconnected and operated as a unit. The terms "anode" and "ground-bed" are in this article used somewhat synonymously. In cathodic protection, the corrosion is in effect transferred from the structure to the buried anode, thus the latter will in time be consumed and need to be replaced.

If the soil resistivity is low and the current requirements small, steel rods driven vertically into the earth can be used as a ground-bed. Junk iron, steel pipe or old rails are often so used. These are consumed at a rapid rate but, if easily replaced, may be more economical than a longer lasting arrangement of greater cost. The use of finely divided coke or "coke breeze" surrounding the buried steel has sometimes been found to increase its life. Carbon and graphite rods also furnish suitable ground anodes. Some difficulty has been experienced in obtaining economical life from carbon rods in salt environments, but specially treated graphite rods have been buried in salt-impregnated earth and even directly in sea water with favorable results.

The physical size of the anode installation usually is designed to insure a reasonably long service life and to provide a resistance low enough to minimize power requirements. For large installations in which costs are substantial, an analysis comparing the annual costs of grounds of various resistances with their power requirements will indicate the optimum combinations. Formulas for estimating the resistance to ground of various shapes, sizes and arrangements of ground electrodes are available (7).

Wires connecting the external power source and the anode or ground-bed will be corroded unless they are insulated along their lengths and at their connection to the anode or ground-bed. Insulation is not necessary for galvanic anodes as the wire also is cathodically protected and need be only mechanically strong. Insulating the wire will, however, serve to prevent waste of protective current.

Cathodic Protection Coordination

Cathodic protection systems properly engineered with full cooperation between the owners of the protected and the adjacent structures should cause no damage to the latter. In fact, such cathodic installations will frequently provide a small measure of protection to the other structures, but this ideal situation can be obtained only with such cooperation. Its need is discussed in Bulletin 1, and it is implemented in Bulletin 2, which outlines procedures for the notification of neighbors if cathodic protection is contemplated. As cathodic protection is an invaluable tool of industry for the mitigation of corrosion, any arbitrary restriction of its use should be avoided. Such restrictions would impair the overall industrial economy and retard the widespread use—which is to be desired—of cathodic protection.

If cathodic protection is applied to a buried structure, some of the protective current will unavoidably stray through the soil to nearby structures.

After traversing these other structures, the current will return in some way to the protected structure. If, in this return circuit, the current leaves the unprotected structure through the surrounding soil or water, that portion of the structure is made anodic and may corrode because of electrolytic action. Under some circumstances, such stray current interference may sometimes become serious.

As has been indicated in Bulletin 2, the extent of the stray current problem depends in general upon three factors: [1] the influence of the particular protective installation, [2] the susceptiveness of the affected structure, and [3] the coupling between the protected and affected structures.

The first factor is largely under the control of the designer of the cathodic system. The second and third are inherent in the structures and their environments, but an understanding of them will assist the designer of the cathodic protection installation to estimate the probable extent of the stray current and foresee what corrective measures may be needed to eliminate damage to other structures.

Influence

"Influence" denotes the inherent tendency of a cathodic protection installation to produce stray currents. It depends upon the amount of current used, location of the anodes or groundbeds, their configuration and resistance to earth and the type of structure (bare, poorly coated or well coated) being protected. For any fixed anode arrangement, type of structure and soil resistivity, the influence is directly proportional to the current. This relationship emphasizes the costliness of using more current than necessary for protection. To reduce undesirable effects on neighboring plant satisfactorily, it may sometimes be necessary actually to use less current than is needed for complete protection.

Most of the protective current enters a bare line relatively close to the anode, so that the stray problem with protected bare lines is usually one of relatively high intensity over a limited area. Even a poorly coated pipeline requires much less current for protection than an uncoated one. With protected, well coated pipelines, the intensity may be lower, but the area of possible stray current effects may be greater. If, however, a line is to be protected in place—or as is—there is no opportunity to alter the coating conditions.

A "large" current may be applied at one location with the objective of having it reach out to protect points some distance away. To minimize the influence, however, several "smaller" currents may be applied at intervals along the line, thus giving more uniform coverage. For example, galvanic anodes supplying small currents at frequent intervals along a line are not likely to create any serious stray current problems, and the sum of these individual currents, although quite adequate for protection, is frequently smaller than the required single point current.

The location of the anode or groundbed relative to the protected structure has a marked bearing on the influence, depending on whether the line is coated or bare. The closer the anode is to a protected, bare structure, the smaller will be the influence. As the distance between the anode and the protected bare structure is increased, the greater is the chance that nearby

unprotected structures will also be included in the circuit.

With coated lines, the distance to the anode is less important, except for its effect on unprotected structures between it and the protected one—the anode should generally be placed to exclude all unprotected structures—that is, the protected structure should lie between any unprotected structure and the anode.

If two structures are more or less parallel, or if they cross and form some reasonably symmetrical arrangement, it is possible to locate an anode for the structure to be protected so that it will have a minimum effect on the other. In practice such uniformity or symmetry is usually lacking, or the required location of the anode or ground-bed, when found, may be impractical for other reasons, but every means of reducing the influence of an installation merits careful consideration.

Susceptiveness

"Susceptiveness" is the inherent ability of an unprotected structure to pick up stray current and discharge it in a manner likely to cause corrosion. The most susceptive structure is an uncoated one, and the least susceptive is a structure with a highly insulative coating. Between these extremes are pipelines with leaky coatings and bare cables in tile or other semi-insulative conduits. A pipeline with a poor coating, if such coating is fairly uniform, is much less susceptive than a bare structure. Poor coatings do not prevent the pickup and discharge of currents, but they distribute them and reduce the probability of concentrated action. Because coating affords protection from stray currents as well as from natural corrosion, it should be considered for new structures to be laid in areas in which cathodic protection systems are likely to be in operation.

Coupling

"Coupling" is the change in potential of a particular unprotected structure when protective current is applied to a nearby structure. Assuming a constant influence and susceptiveness, the tendency of a cathodically protected structure and its anode to cause the flow of current in a nearby structure depends upon the earth resistivity and the physical separation between the structures. The closer the spacing between the structures, the greater usually will be the current picked up and discharged by the unprotected one. This is particularly true where lines cross near an anode, or where two parallel lines have branches that cross.

For a given configuration of lines, the coupling increases with earth resistivity. With relatively high earth resistivity—more than 10,000 ohm-cm. or 100 meter-ohms—and resultant high coupling, however, certain favorable conditions result, so that [1] a relatively small current will establish protection of the one line, and [2] the stray current is likely to leave the unprotected line over a wide area and thereby disperse its corrosive effect.

If earth resistivity is low, the resultant coupling is also low, but the currents involved are likely to be large and to be picked up and discharged by the unprotected line within short distances, thus creating a greater problem. If lines are close together, such as under a single roadway, it appears that the most favorable condition is high earth resistivity. For larger separations, the most favorable con-

ditions are those of low earth resistivity and sufficient distance from the unprotected structure to minimize the coupling.

Mitigation of Effects

Some portions of pipe and cable systems suffer damage by electrolysis that is caused by strong stray currents leaking from d-c.–operated electric traction systems having a grounded return. Unless properly mitigated, this damage occurs as the current leaves the structures. Those portions of the structure receiving the current from the soil, however, are afforded varying degrees of cathodic protection. Where such because of transition to double trolley and motor bus operation, pipe and cable systems have been relieved of the electrolysis, but they have suffered much more corrosion from other causes because of the removal of the wide measure of cathodic protection previously provided by properly mitigated stray rail currents. As a result, many pipe and cable operators in those areas have had to install their own cathodic protection and are consequently having to cooperate with others in solving these new interference problems of their own making.

Street railway electrolysis has been the object of cooperative study and mitigative effort since it was first recognized about 1910. An interindustry committee issued a classic report (8) on the subject in 1921. Although cathodic protection as a safeguard against soil corrosion is reported to have been used as early as 1922, its effectiveness was not generally recognized until 1933 (9, 10). The procedures used today to measure and stop cathodic system interferences are much the same as those developed years ago to combat street railway electrolysis. In metropolitan areas, where subway, elevated and some surface railway lines remain, the mitigation of stray-current electrolysis is still a major problem.

When installing or replacing buried plant, consideration should be given to the use of coatings in areas in which cathodic protection systems are likely to be in operation on adjacent structures. The more difficult problems generally arise if the existing plant is extensive and bare, and if cathodic protection is desired. In such circumstances the engineer has no opportunity to use coatings or to select routes that will avoid stray currents.

If several separately owned structures are experiencing corrosion in the same area, every consideration should be given to the use of joint cathodic protection, as described in Bulletin 4. If this method is not practicable, the first duty of the operator installing cathodic protection should be to notify the owners of adjacent plant of his intention, as described in Bulletin 2, and to enlist their cooperation in determining how best to avoid effects of stray currents.

For such cooperative effort, it seems impracticable to set down general rules of procedure. From time to time cathodic protection will be used by many diverse owners of underground plant, and the job of investigating stray cathodic protection current effects will fall first on one owner and then on another. It therefore seems equitable for each owner to handle the testing work for his own plant. It also seems clear that each owner should be the judge of the protective requirements of his plant. This latter prerogative, although basic, should be exercised with sound engineering judgment and an avoidance of purely arbitrary decisions.

The cathodic protection system should generally be designed with a view to limiting its influence. Distributing the current along the protected structure and using the minimum current consistent with good performance will often reduce stray current to negligible amounts. If such measures are not feasible, consideration should be given to the placing of resistance bonds between the protected and disturbed structures. The locations of these bonds will depend on circumstances.

If the anode or ground-bed is close to the disturbed structure, stray current will generally be picked up in the adjacent sections, and discharged back to the protected line at more remote points. In this case, the most suitable location for interstructure bonds would therefore seem to be at the discharge points. These joints, however, may not be practicable. It may be better to select a more desirable location for the ground-bed or, if this is not possible, to restrict the current pickup by properly installed insulated joints. If the ground-bed is some distance from the disturbed line, the stray currents may be collected at remote points and returned toward the power supply point where they are discharged into the soil. To cope with this situation the best location for bonding is usually at the power supply point. The collection and discharge areas should be determined by test, however, as the many variables involved render the prediction of their location impractical.

If bonding offers a solution, the total bond current required to provide satisfactory conditions must be determined. The operator installing the system will wish to keep this current at minimum because of additional power cost. One gage of proper bond current is to drain from the disturbed structure just enough current to reduce to zero the stray protective current discharged to earth. This reduction is usually accomplished by making most of the disturbed structure more cathodic than it was before the problem arose, so that it actually receives a slight degree of protection.

If the disturbed structure has a much higher resistance to ground than the protected structure, the bond currents are relatively small, and thus low-resistance bonds can be placed without substantially increasing the total current requirements of the protected structure. If that arrangement is impossible, bonds of specific resistances must be used. These resistances can be estimated from test data, but their final values are best determined experimentally by adjusting the resistances of temporary bonds until the desired condition is obtained. To reflect only the changes produced by the stray protective current, the tests should be made with the cathodic protection system both off and on. Then only the changes produced by its operation should be considered. Proper bond installation and adjustment, should eliminate the adverse effects of cathodic stray current.

Cathodic Protection Bibliography

Published literature contains many articles on the various aspects of cathodic protection. A bibliography (11) lists 436 such articles published before 1950. Many of these have been written by recognized leaders in the field, including individual members of this correlating committee. The official magazine, *Corrosion,* of the National Association of Corrosion Engineers each month currently extracts nearly all recent articles on all phases of cor-

rosion control. A number of representative articles are listed (12–62) as a guide to the engineer who seeks further knowledge of cathodic system design and cathodic interference mitigation.

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APPENDIX

Technical Practices Committees of National Association of Corrosion Engineers Dealing With Cathodic Protection Problems

TP–2	Galvanic Anodes for Cathodic Protection *
TP–3	Anodes for Use With Impressed Currents
TP–4	Minimum Current Requirements for Cathodic Protection
TP–6	Protective Coatings
TP–8	Effects of Electrical Grounding on Corrosion
TP–14	Instruments for Corrosion Measurements
TP–16	Electrolysis and Corrosion of Cable Sheaths
TP–17	Standardization of Procedures for Measuring Pipe Coating Conductance

* See Reference 5.

This is the final report of a series of four, prepared by the Correlating Committee on Cathodic Protection—an interassociation group in which the A.W.W.A. was represented by A. R. Davis and F. E. Dolson.

The text of the report has been edited to conform with Journal style.

It is anticipated that the four bulletins will be consolidated into a "Final Report of the Correlating Committee on Cathodic Protection" to be published soon by the National Association of Corrosion Engineers, 919 Milam Bldg., Houston, Tex., for sale at nominal cost to all interested parties. Inquiries and orders for this book should be directed to the N.A.C.E. office.

Water Supply in Finland

By Amos J. Alter

A contribution to the Journal by Amos J. Alter, Director, Div. of Sanitation and Eng., Territorial Dept. of Health, Juneau, Alaska.

SINCE development of the first community water supply system in Helsinki in 1876, water supply practice in Finland has changed greatly. Low temperatures, wars, changes of government, retarded industrial development and a rigid economy delayed community water supply development in some regions. These same impediments, however, have also stimulated relatively recent interest in water supply improvement. Growing communities and new industries demand adequate and safe supplies. Finnish water supply practice is changing to meet these needs. Several modern purification units are now under construction.

Physiography and Population

Geological action in Finland during the Pleistocene epoch formed more than 60,000 natural lakes covering 10 per cent of the land area. These lakes are scattered throughout the entire country but are most numerous in the southeastern third of it. Rock, which is relatively close to the ground surface, lakes, many irregular hills of gravel and lowlands of poorly sorted debris, are characteristic of the entire country. Elevations above sea level range from 0 to 30 ft. in the coastal areas along the Gulf of Bothnia and the Gulf of Finland, from 300 to 600 ft. in the Finnish Lowland (central, south-central, and southeastern Finland), from 600 to 1,500 ft. along the northern Russo-Finnish border and on the Lapland Plateau (northcentral Finland) and from 1,600 to 4,300 ft. in the mountainous northwestern border regions adjacent to Norway and Sweden. The glacial ice deepened mountain valleys, polished rock surfaces, scoured such lake basins as the Inari lake region in north central Finland and left numerous eskers—the narrow ridges and mounds of sand-and gravel-drift from subglacial streams.

Approximately 65 per cent of the land is timbered with predominately coniferous trees. Birch trees are common, and, in some parts of the Lapland Plateau, tundra vegetation exists.

Since World War II Finland has an area of approximately 125,000 sq. miles —slightly greater than that of New Mexico. Although some cities of Finland are almost 600 years old, most communities date back approximately 300 years.

Of the total population of almost 4,000,000, approximately 70 per cent is rural. There are more than 900 cities and villages, but less than 100 have a population greater than 1,000.

Finland is located at 60–70 deg. North latitude, and the climate is subarctic. The warming effect of the Gulf Stream makes it much warmer than

TABLE 1

Community Water Supplies in Finland

Community	1949 Pop.	Yr. Plant Built	Source—*per cent*		Avg. Use *gpd.*	Pop. Served *per cent*	Treatment*
			Ground	Surface			
Helsinki	359,813	1876	1	99	48	90	D, F, C, S, T
Turku	99,274	1903	11	89	40	86	D, F, C, S
Tampere	95,753	1897		100	42	80	D, F, S, C
Lahti	42,364	1909	100		42	65	C, S
Pori	41,353	1935		100	37	50	D, F, C, S
Oulu	36,073	1901		100	53	75	D, F, C, S, T
Vaasa	33,994	1915	25	75	53	66	D, F, C, S, A
Kuopio	31,255	1938		100	26	95	D, F, C, S
Jyväskylä	28,682	1941	50	50	46	66	D, F, C, S
Kemi	23,387	1940		100	49	30	D, F, C, S
Kotka	22,930	1906		100	36	100	D, F, C, S, T
Hämeenlinna	21,199	1910	100		65	80	F, A
Varkaus†	16,858						
Mikkeli	16,475	1911	100		16	75	D, F, A
Lappeenranta	16,380	1927	100		44	47	None
Riihimäki†	15,681						
Nokia†	14,922						
Rauma	14,684	1934		100	37	83	D, F, C, S
Rovaniemi	13,721	1939		100		8	None
Kokkola	12,826	1914	100		28	60	D, F, A
Savonlinna†	10,995						
Hyvinkää	10,536	1945	100		26	33	None
Valkeakoski	10,173	1937		100	40	35	None
Kajaani	10,077	1920		100	27	50	D, F, C, S
Lauritsala	9,975						
Kouvola	9,000	1941	100		79	33	None
Salo	8,982	1938	100		28	76	Unknown
Forssa	8,870	1941		100	30	25	D, F, C, S
Porvoo	8,478	1914	100		44	75	D, F, A
Jakobstadt†	7,836	1926	100		37	?	D, F, A
Joensuu	7,615	1927	50	50		90	F, C, S
Kerava†	7,435				59		
Seinäjoki	7,390	1922		100	46	83	D, F, C, S
Pieksämäki†	7,256						
Hanko	6,778	1910	100		13	75	
Lohja	6,748	1940	100		98	20	
Hamina	6,500	1936	100		13	50	F, C, S
Äänekoski	6,099	1942		100		?	
Toijala†	5,604						
Suolahti†	5,045						
Heinola	4,892	1930		100	15	10	
Karkkila	4,466	1942	50	50	24	60	
Tammisaari	4,442	1929	100		29	90	
Iisalmi	4,422	1932		100	20	88	D, F, C, S
Loviisa	4,362	1938	100			37	
Raahe	4,344						
Uusikaupunki†	4,099						
Karjaa	3,809	1940	100			30	
Lieksa†	3,539						
Maarianhamina†	3,506						
Kristiina†	3,500						
Tornio	3,409	1925		100			F, C, S
Loimaa†	3,322						
Kauniainen†	2,279						
Naantali†	1,918						
Kaskinen†	1,758						
Nurmes	1,504	1940		100	17	98	None
Vammala†	1,124						
Uusikaarlepyy†	1,066						
Ikaalinen	456	1922		100		100	

* Treatment Symbols: A—Aeration; C—Chemical coagulation; D—Disinfection; F—Rapid Sand Filtration; S—Sedimentation; T—Taste and odor control.

† Water system, treatment plant, or both, planned or under construction.

such areas in similar latitudes as northern Alaska, Siberia and northern Canada. Mean annual precipitation ranges from 16 to 28 in. (Fig. 1), and mean annual air temperature ranges from 26° to 40°F. (Fig. 2).

Wood products, lumbering, agriculture and textile manufacturing are the chief industries. Utilization of the forests of Finland provides the principal livelihood. Many pulp mills make paper for export to Russia, England and several other countries.

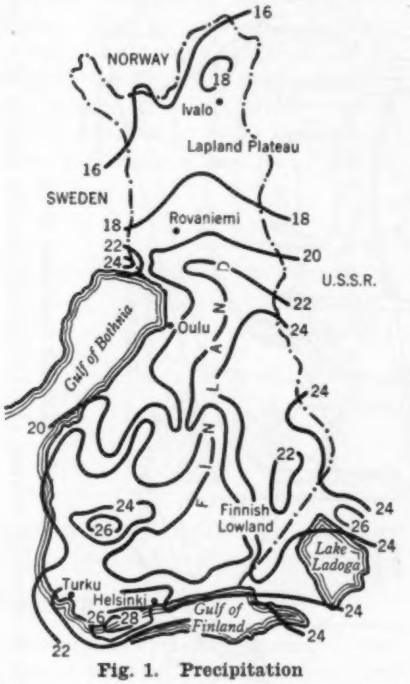

Fig. 1. Precipitation

Numerals indicate inches of mean annual precipitation.

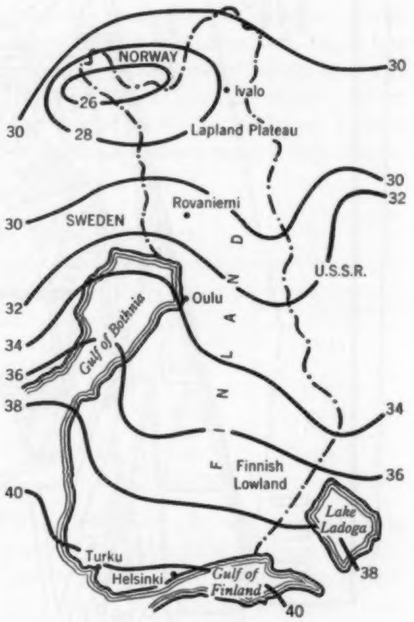

Fig. 2. Air Temperature

Numerals indicate mean annual temperature in degrees Fahrenheit.

Sources of Supply

Both surface and ground water sources offer an adequate supply of water in most areas. Approximately as many communities depend upon ground water as a source of supply as depend upon surface supplies. The larger communities and industries such as pulp mills use surface water. Table 1 lists the principal community water supplies.

Except in some of the rivers which receive industrial wastes, most surface waters are relatively free of pollution. Industrial wastes make taste and odor control necessary in a few areas. The surface waters are often humus colored and are warm in summer and cold in winter. Total hardness ranges from 10 to 30 ppm. expressed as $CaCO_3$. Coagulation, settling, rapid sand filtration and chlorination are common treatment methods. Aeration, activated carbon application and chlorina-

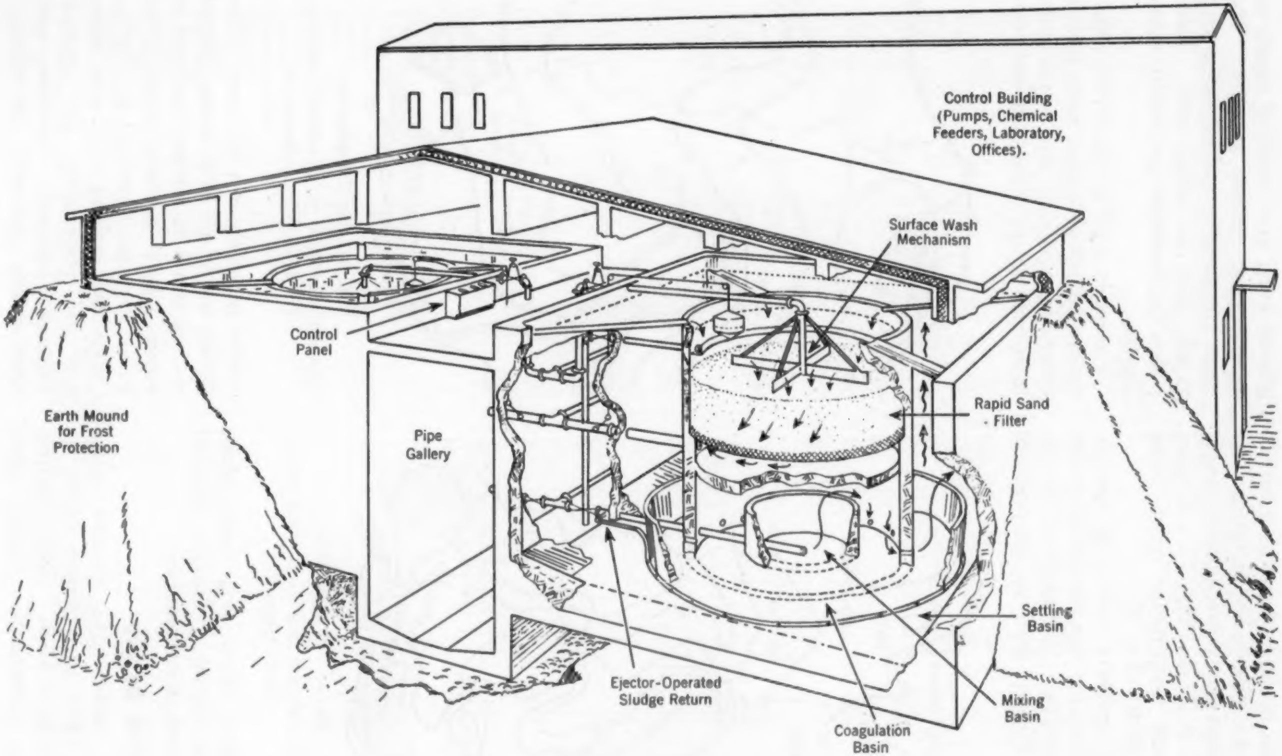

Fig. 3. Jakobstad Treatment Plant

This schematic diagram shows the mixing, clarification and filtration sections of a typical filtrator unit.

tion are used in taste and odor control of some surface waters.

Ground water supplies do not usually produce more than 500–800 gpm. Supplies for small communities and single premises come predominately from wells. Ground water from the eskers rarely requires treatment. Other types of ground water usually contain too much carbon dioxide and iron and occasionally too much manganese. Most ground water, however, is clear and soft—hardness usually ranges from 15 to 110 ppm. expressed as $CaCO_3$. Ground water temperatures are higher in winter than surface water temperatures, and it is therefore much easier to distribute ground water under low-temperature conditions.

Pollution

Finland is currently starting a program of treatment for community and industrial wastes, but the largest rivers receiving industrial wastes are still undesirable for public water supply. The Vuoksi, Kyminjoki and Kokemäenjoki rivers are the worst polluted, as they receive a great deal of waste fiber and caustic solutions as well as other wastes.

Portions of Kuopio and Mikkeli provinces were probably inundated by salt water at one time, and much of the ground water of this region has high concentrations of salt, iron, manganese and organic matter. In this portion of the lowland area, streams are sluggish and some surface waters are bacteriologically polluted. This pollution has resulted in generally unsafe water and a relatively high incidence of gastrointestinal illness. Savonlinna and Lieksa have suffered continuously from paratyphoid. Savonlinna is located on a rocky terrain which has made the cost of water works improvements comparatively high, but they are now under consideration. The people of Lieksa obtain water from the reportedly polluted Lieksa River, which flows across the Russo-Finnish border. It has not yet been possible to treat the Lieksa supply. Ground water is not satisfactory in this area, and international pollution control has not yet been possible for the Lieksa River.

TABLE 2

Gastrointestinal Morbidity in Finland 1943–48 (1)

Year	Total Pop.	Typhoid	Paratyphoid	Dysentery	Acute Gastroenteritis. Cause unknown
1943	3,632,315	369	1424	97	29,149
1944	3,675,099	560	3795	645	42,323
1945	3,693,267	783	8537	476	49,885
1946	3,737,793	609	3970	207	44,323
1947	3,848,435	813	2957	102	51,121
1948	3,910,572	313	1598	66	44,425

Intestinal Illness

Significant numbers of cases of typhoid, paratyphoid, dysentery and acute gastroenteritis from unknown causes are reported annually (1). Epidemiological data and the relationship of these reported cases to water quality are not available, but morbidity for the years 1943–48 is shown in Table 2.

Within the last three years, additional treatment has been provided for some water supplies and the national health agency, Lääkintöhallitus, has engaged the part-time services of a sanitary engineer, who has placed much emphasis on community water supply improvement.

Treatment Practices

The oldest treatment plants are of conventional design and similar to installations in the United States. More recent plants have employed a thinner layer of larger particle sand in rapid sand filters than is ordinarily standard. Surface washing of the sand with jets of water at the surface of the filter is common.

The newest water treatment plants have employed filtrator * units and have been designed to minimize the effects of low temperatures. These units are used for coagulation, clarification and filtration and are applied to iron removal or plain chemical treatment for surface waters. The unit is also suitable for softening water but is not at present used for this purpose. The usual installation is open to the atmosphere, but units with capacities of approximately 50 gpm. or less are constructed as pressure units.

Fig. 4. Filtrator Type Plant Controls

These control mechanisms are from the Jakobstad water plant.

The mixing, reaction, clarification and filtration sections of a typical filtrator unit are shown in Fig. 3. Raw water is pumped into the flash mixing section parallel to a tangent to the cylindrical chamber. Pressure of the incoming water is utilized to effect mixing without further mechanical action. Reaction takes place in the second cylindrical basin, which is also the base of the rapid sand filter in the upper part of the unit. Reaction con-

* A purification unit designed by Osmo Makkonen and Osakeyhtiö Yleinen Insinööritoimisto, Helsinki, Suomi; patent application 1241/49.

tinues in the third cylindrical basin after the water has passed through the ports in the side of the initial reaction chamber. Water passes through the ports to the final reaction chamber at approximately 1–1½ fps. As the water moves from the center to the outside of the concentric cylindrical basins, the velocity is reduced until it is the proper rate for clarification in the outer or clarification chamber. The clarification chamber is sometimes of cylindrical construction but also may be constructed in the shape of a box. Upflow clarification is achieved by passing the flocculated raw water upward through the sludge blanket in the bottom of the clarification basin. Clarified water at the top of the basin passes over the circumference of the cylindrical filter as well as through troughs extending from each corner of the square clarification chamber to the centrally located filter.

Coagulation is activated by returning part of the sludge from the bottom of the clarification chamber to the mixing chamber. A perforated pipeline in the bottom of the clarification chamber removes the sludge. An injector fitted into the raw-water line draws sludge through the perforated pipeline and into the raw-water line. Old floc forms the nucleus for new floc and thereby greatly reduces the reaction time. Excess sludge may be removed continuously or intermittently, as may be necessary.

The filter is a conventional rapid sand filter which is washed both countercurrent and with surface wash. Treated water is used for washing. Approximately 11 gpm. per sq.ft. is used for the countercurrent wash rate and about ⅔ gpm. per sq.ft. is used for the surface wash. Surface washing is accomplished with a rake operated by the water pressure. Flow is controlled by a float on the filter surface.

Nine filtrator type plants are now in use or under construction in Finland. These plants minimize the problems of low temperature operation, reduce mechanical equipment to a minimum, require less chemicals for operation, permit shorter reaction and clarification time and extend the filtering sequence. Control apparatus of the filtrator type plant, now under construction at Jakobstad, Finland, is shown in Fig. 4.

Distribution and Storage

Cast-iron, steel, wood-stave and asbestos-cement pipes are the types most commonly used for the distribution systems. Climatic conditions necessitate a minimum cover of 7½ ft. for all distribution lines. Fire hydrants are generally of the European type, consisting of valves placed in manholes so that no part of the fire connection extends above street grade.

Several unique methods have been used in providing elevated water storage that is protected from low temperatures. One such method was the construction of a standpipe of concentric cylinders of wood-stave pipe. The city of Kemi has incorporated an elevated storage tank into the modern design of a town hall that has eight floors of offices and a civic center under the tank.

Acknowledgment

The author gratefully acknowledges the willing assistance given to him by so many persons in Finland during his visit to that country. In particular, Osmo Makkonen of Helsinki, Finland, offered invaluable help.

Reference

1. *Statistical Yearbook for Finland.* Valtioneuvoston Kirjapaino, Helsinki, Finland (1950).

Frost Penetration in Montana Soils

By John W. Hall

A paper presented on April 21, 1951, at the Montana Section Meeting, Helena, Mont., by John W. Hall, Cons.. Engr., Fort Shaw, Mont.

LONG periods of extremely cold weather, in the absence of snow, can deal out more misery to the water superintendent than all other troubles combined. No other single subject has caused so much discussion among water works men, especially after a cold, open winter. These questions continually arise: "How deep should water mains be buried?" and "How much trouble has frost caused?"

No person can give advice on the depth to which water mains should be buried to prevent freezing unless he is provided with detailed information.

From December 1936 to March 1937, the author observed the rate of frost penetration in different soils. These tests revealed so little new information that they were not originally made public. After a period of reflection, however, it was concluded that some of these results were unique and should therefore be made known.

Many factors, some of which are unknown to the author, influence the depth of frost penetration and the rapidity at which it advances. Factors directly affecting frost penetration are:

1. Air temperature and its duration
2. Character of the soil
3. Amount of moisture in the soil
4. Density of the soil
5. Texture of the soil
6. Color of the soil.

Test Procedure

During November 1936 ten test holes were drilled at Fort Shaw, Mont., in various soils within a quarter-mile radius. The holes were of 8-in. diameter and 8 ft. deep. A 6-in. stopper, packed with Zonolite,* a highly satisfactory insulator, was used as a plug and removed once daily at 10 A.M. for an observation period of not more than 20 seconds. The frost could be observed as a whitish covering on the inside surface of the hole, and inverted scales, graduated to tenths of a foot, were installed in the holes to permit quick and accurate readings. Snowfall during the period of observation was rather light and was immediately removed, as snow is a good insulator and would therefore greatly retard the rate of penetration.

Penetration was deepest and fastest in the hard, compacted sand and gravel containing a fair amount of moisture (Fig. 1). Unless penetration is studied for an extended period, it is believed that results will be inconclusive.

It is the author's belief that, if a soil were absolutely devoid of water, the only frost that could form would be that induced in the top few inches because of the moisture in the air. The depth of penetration of the frost, it is believed, is directly proportional to the amount of moisture in the soil. Figure 1 shows that, in materials of practically the same character, frost penetration is most rapid and deepest in soils containing the most moisture. At the point of saturation, however, frost is stopped permanently, as is attested by

* A product of Robinson Insulation Co., Great Falls, Mont.

the well known fact that pipes buried below the water table will not freeze.

To afford the reader a general pattern of average frost penetration for an extended period throughout the United States, Figure 2 is included.

thaw approaches the point of deepest penetration, the frost continues downward while melting proceeds above. This descent may sometimes be as much as 6–8 in. and is unquestionably responsible for many freezings that occur during warm weather while the frost is leaving the ground. Frost will often travel along the hydrant rod for as much as a foot and freeze the valve at the bottom, thus rendering the hydrant useless.

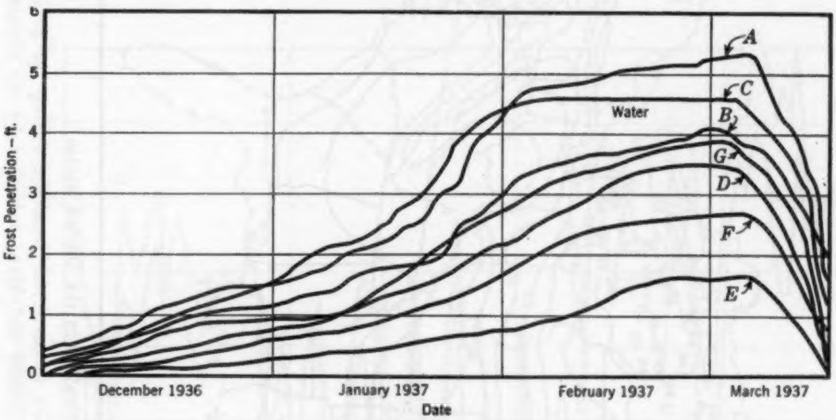

Fig. 1. Variations in Frost Penetration

A daily record of frost penetration in seven of the test holes at Fort Shaw, Mont. No. 1 hole was dug in the road.

Key

Line	Hole No.	Composition	Characteristics
A	1	30% sand; 70% gravel	Hard and damp
B	2	30% sand; 70% gravel	Slightly damp
C	3	30% sand; 70% gravel	Very damp
D	4	30% sand; 70% gravel	Very dry
E	5	100% black loam	Very dry
F	6	80% black loam; 20% gravel	Slightly damp
G	7	100% yellow gumbo	Very hard and dry

Frost penetration is probably not directly proportional to the temperature level. If frost descends 1 in. during 24 hours when the weather is 30° below freezing, it will not necessarily descend 2 in. during 24 hours if the temperature is 60° below freezing.

Long, continuous cold drives the frost down. If short periods of thaw occur after each cold spell, immediate relief is obtained, because when the cold weather reappears, some time is required for the frost to penetrate again into the soil which thawed out. If the thaw approaches the point of deepest penetration, the frost continues downward while melting proceeds above.

Figure 3 gives a temperature record of a period of bitter cold that started on January 1, 1937. This period of subzero weather did not let up until February 9. At the time of its inspection, on January 1, No. 1 hole showed approximately 1½ ft. of frost. By February 9 penetration in this hole had in-

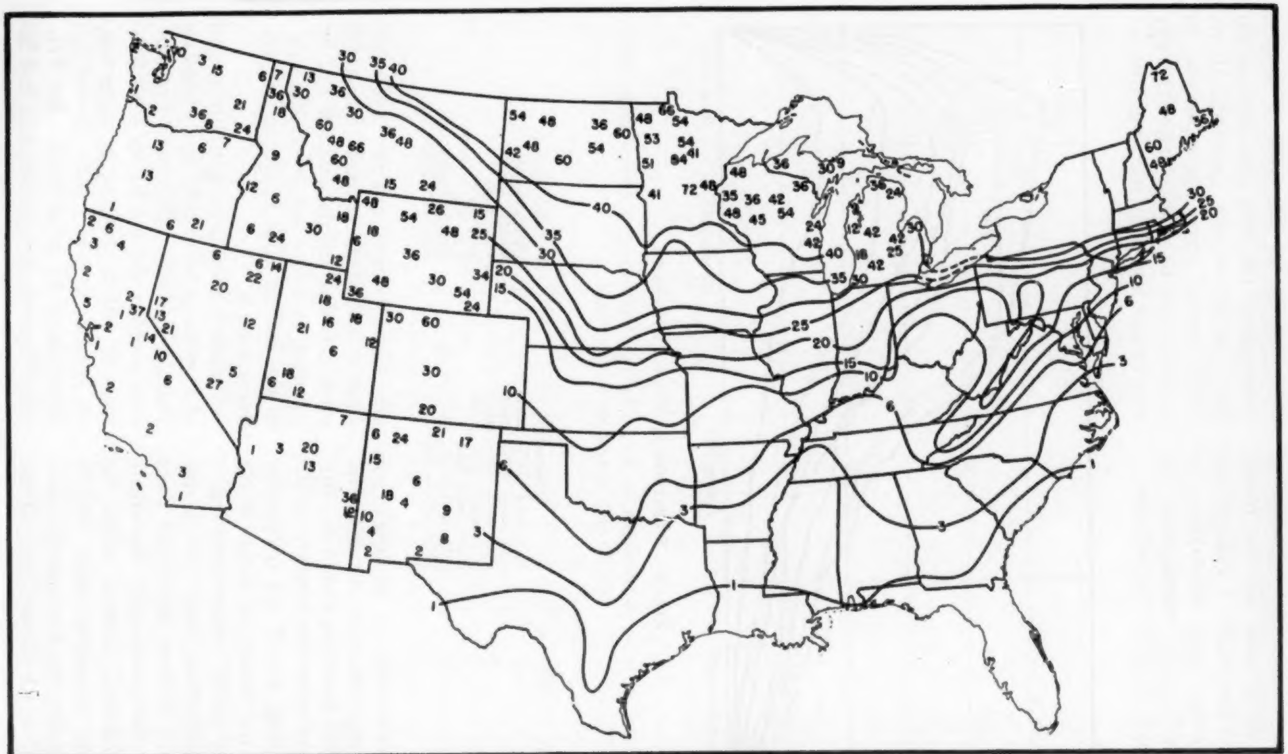

Fig. 2. Average Depth of Frost Penetration in the United States

The numerals indicate the average number of inches of penetration in particular localities during the period 1899 to 1938. This map is reproduced from the 1941 Yearbook of Agriculture—Climate and Man, *published by the Weather Bureau, U.S. Dept. of Commerce, Washington, D.C.*

creased to approximately 4½ ft., or approximately 1 in. for each 24 hrs. It would be natural to assume that, as the period of cold continued, the rate of penetration would have abated, but Fig. 1 and 3 do not bear out this assumption.

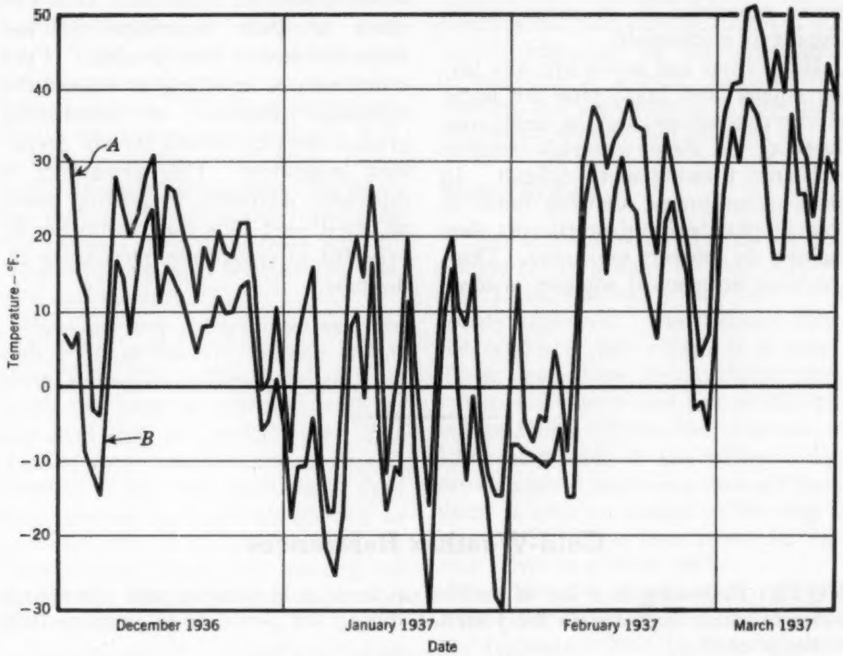

Fig. 3. Temperature Variations

A daily record of temperature variations at Fort Shaw, Mont., is presented. Curve A *represents the mean average daily temperatures, and Curve* B *represents the minimum daily readings.*

No reasonable explanation for the inconsistency of frost penetration seems to exist. With exactly the same materials, moisture content, and apparently the same density and color, holes only 3 ft. apart provide different results. Unknown and confounding factors obviously operate to affect the results.

Intensive study for an extended period of years may lead to the development of a mathematical formula which will be of some use to the water works profession in determining the minimum depth that water pipes can be laid with safety from the hazards of frost.

Depth of Mains

How deep should a water main be buried to protect it from the frost? Any answer to this question must be based first on a knowledge of the characteristics of the soil. It must be determined whether the soil is sand, gravel, loam, gumbo or any combination of the four; firmly packed or loose;

wet or dry and, if wet, how much water it contains.

It is suggested that all Montana water mains and house service connections, regardless of character of the soil in which they are laid, be buried a minimum of 6½ ft. The additional depth of trench will cost very little more, especially as so much trench digging is mechanized.

Many cities and towns are now laying copper and brass pipe for water service connections, and the better conductivity of these materials renders resistance thawing more difficult. In most union towns, thawing must be done by plumbers and electricians, thus making the job very expensive. Thus, the most economical solution is obviously that of burying pipe below the known frost line.

Before installing water mains in newly developed areas, the engineer should ask the community's governing body to establish a system of grades. Many pipes laid sufficiently deep to afford protection from frost have had much of their coverings removed when the streets were graded. If the community is unwilling to assume the additional expense of establishing grades, the pipe should be laid deeper than ordinarily. This precaution is especially advisable if grading work on knolls and hills can reasonably be expected to reduce the overburden on the pipe.

Cold-Weather References

NOTE: Following is a list of articles on frost, cold weather and other such subjects which appeared in the JOURNAL during the period from January 1936 to the present:

1. WILLS, W. COMPTON. Frost Difficulties and Experiences During the Past Winter at Wilmington. July 1936, p. 837.
2. HECHMER, CARL A. Frost Difficulties and Experiences During the Past Winter. July 1936, p. 841.
3. GAYTON, LORAN D. Unprecedented Low Temperatures and Their Effect on the Chicago Water Supply System. July 1936, p. 849.
4. AMSBARY, FRANK C., JR. Thawing Service Pipes. July 1936, p. 856.
5. INDIANAPOLIS WATER CO. Freezing Troubles in Indiana Towns and Cities for Winter of 1935–36. Aug. 1936, p. 1062.
6. PEIRCE, WALTER A. 1935–36 Cold Weather Experiences in Wisconsin. Jan. 1937, p. 2.
7. MABEE, W. C. Lessons From the Winter of 1935–1936. Jan. 1937, p. 7.
8. LEIPOLD, CARL. Raising Water Temperature During Severe Winter. June 1937, p. 866.
9. MACDONALD, W. E. Winter Season Control of a Water Works System. Dec. 1937, p. 1890.
10. FARRA, ELWOOD. Maintaining Water Service in Sub-Zero Weather. Dec. 1940, p. 2060.
11. RIDDICK, THOMAS M.; LINDSAY, NORMAN L.; & TOMASSI, ANTONIO. Freezing of Water in Exposed Pipelines. Nov. 1950, p. 1035.

Cold-Weather Operation of Distribution Systems

By E. J. Van Deusen

A paper presented on Sept. 7, 1950, at the New York Section Meeting, Upper Saranac Lake, N.Y., by E. J. Van Deusen, Supt., Dept. of Water, Malone, N.Y.

COLD weather is not particularly troublesome in northern New York State, because it is anticipated and plans to cope with it are made before its arrival. The frost in the area usually penetrates approximately 4 ft. in the part of the street where heavy traffic and snowplows remove the snow, but, during a winter of much snow, no more than 1 or 2 ft. of frost may develop below the area between the sidewalk and the curb.

Pipelines and service lines are laid with 5 ft. of cover. Service is not given to houses without cellars. If mains are kept in gridirons with as few dead ends as possible, very little trouble from frozen mains is experienced. At the few unavoidable dead ends, service taps are maintained as near the ends as possible to keep the main open or indicate any freezing immediately. Such service taps also facilitate thawing.

The Malone, N.Y., water works does not have a thawing machine and does not pay for thawing service lines. A local garage has a machine and charges $10.00 for the thawing operation regardless of the time involved. If the service line is attached to a dead end, the department pays to thaw it as it is impossible to determine whether the main or the service line froze.

During the winter nights, many customers let the water run to avoid freezing of the lines. As a result the night consumption is approximately half the daytime amount. The installation of domestic meters would probably halt this practice, but it is not too objectionable, for the night draft in winter is no greater than in other seasons, and undoubtedly it helps prevent many service difficulties.

Water System

The Malone water system is fed completely by gravity through a 10-in. and 12-in. line on either side of a county highway. The distance from the intake to the village is 8 miles. These lines have a continuous flow into a reservoir located just outside the village limits. From the reservoir, a 12-in. line leads to the village. Approximately 2 mgd. flow through these lines, so that no danger of freezing is presented. These lines cross the Salmon River at a 60-ft. bridge.

In February several years ago, the river filled with anchor ice and flooded the highway. The highway department, either not knowing or not caring about the water pipe, dropped dynamite over the side of the bridge and split open the 10-in. main. Quick action was required, as loss of this line cut off half the town's supply.

As it was impossible to make repairs in the river until the water was at a lower level and considerably warmer, the 10-in. line was cut on the south side of the bridge and brought up to one side of the roadway on the bridge and back down on the north side. Several heavy snowstorms and much

cold weather occurred during the rest of the winter, but temperature of the 10-in. line kept the bridge floor free of snow and ice. The repairs in the river were easily made in the spring.

Hydrants

Hydrants present the major wintertime problem in northern New York State. When a water works man hears the fire siren in the middle of the night, and the temperature is twenty below zero, his first thought is: "Is the hydrant working?" Malone uses 6-ft. hydrants so that 5–5½ ft. of cover is provided. Each hydrant is equipped with a valve at the main and is so placed that it is on the same side of the street as the main. This practice makes unnecessary long lines from the main to the hydrant under the street—the area of deepest frost penetration.

In the installation of a hydrant, special care is given to construction of the well, which is made deep and wide —at least 5 ft. in diameter. This diameter provides approximately 2 ft. on each side of the heel. In clay soil, even larger wells are dug. The well is filled with large, round 6–10-in. diameter stones and built up at least 1 ft. above the drain. The top is covered with smaller stones to fill voids, and prevent backfill from entering the well. Hydrants with 5 ft. of cover and good wells operate efficiently.

Each fall, all hydrants are inspected, blown out, checked for leaks and given necessary repairs. During the winter, hydrants are opened only for fires. If a hydrant is set in ground water, the drain is plugged, and 1–2 gal. of antifreeze is poured in.

Hydrants are most troublesome during February and early March, when the frost is leaving the ground. Part of the frost seems to descend at that time, as hydrants may freeze after a long period of mild weather.

After each snowstorm water department men follow the street plows and dig out the hydrants. Not all the snow is removed, as it protects the hydrant from frost. If it is necessary for the fire department to use the hydrant, it is uncovered completely and made ready for service. Water men follow the fire department to fires in winter and drain a hydrant after use.

About the middle of February, inspection for frozen hydrants is begun. A few always seem to be more susceptible to frost than the rest, and, if any of these are frozen, the inspection is extended to the others. Inspection consists in cracking the valve, and shutting it immediately if water is heard. If the hydrant is frozen, thawing can usually be accomplished with a small, oil-burning boiler that holds approximately 3 gal. of water and carries approximately 20 psi. of steam. Even if the branch line is frozen, these boilers, or larger ones, are effective once the hydrant valve is open. When the hydrant has been opened, the water is allowed to run for several minutes to remove some of the frost from around the pipe. The hydrant is then pumped out and tested daily until all frost is out of the ground. The hydrant needs new leather valve packing after steam has been applied.

No hydrants are installed or service taps made after the ground has become frozen, as frozen ground should never be used as backfill.

Frozen water pipes seem to occur in cycles. Every few years a winter with little snow but much cold weather causes an epidemic of freezing. If, however, there is a heavy snowfall, particularly if it occurs before cold weather and remains down until the middle of March, frost problems are slight.

Relation of Frost Penetration to Underground Water Lines

By James Petrica

A contribution to the Journal by James Petrica, Designer, Whitman, Requardt & Assoc., Baltimore, Md.

THE line defined by the points of greatest depth at which soil freezes is known as the "frost line." Water distribution system operators and designers are interested in the relation of this line to the depth at which water mains are laid. The operator's problem is to estimate the possibility of freezing of an existing water main; the designer's problem is to estimate the depth of the frost line for given conditions to determine at what depth pipe should be laid to avoid freezing. The extent of these problems is greater than is generally recognized.

An examination of some of the U.S. Weather Bureau records (1) will show that the average temperature for the month of January is less than 32°F. in some of the larger cities of 31 states. These states include New Jersey, Pennsylvania, West Virginia, Ohio, Indiana, Illinois, Missouri, Kansas, Colorado, New Mexico, Arizona and all states north of them except California and Oregon. Whereas these are average temperatures, subzero extremes have been reported from cities in 46 states. It is therefore obvious that water mains in most of the United States may be exposed to freezing.

Location of the Frost Line

The most important factors that affect the location of the frost line are the type of soil, average yearly temperature of the ground, time from the start of freezing temperatures and snow or pavement cover. The depth of the frost line thus varies from place to place at a given time and from time to time at a given place. Meteorological factors such as wind velocities and the amount of sunshine and clouds affect the frost line somewhat but can usually be disregarded.

The frost line does not ordinarily follow the points at which the ground temperature is exactly 32°F. Soil moisture may start to freeze only at temperatures ranging from 31.1°F. to 31.96°F. Since water in distribution lines may be under service pressures of 30 to 100 psi., the freezing point in the lines may vary from approximately 31.87°F. to 31.96°F. For practical considerations, however, governing temperature for the frost line and the freezing of water will be assumed to be 32°F.

Analysis of the problem is based on a study of the ground-to-air heat transfer when the temperature of a portion of the ground is above 32°F. and that of the air is below 32°F. Transmission of heat is effected through conduction, convection and radiation.

Conduction is the process by which heat energy from one solid particle is transmitted to an adjacent solid particle by the violent vibrations of

molecules without mass motion of the particles. This process occurs throughout a soil if a temperature differential exists between the layers of soil.

Conduction also takes place between the soil, water main and water when there is a temperature differential. The surface of the ground is continuously losing heat to the air by radiation and convection, with the result that the temperature differential between them becomes equalized. Changes in temperature progress throughout the depth of the ground by conduction of heat from the warm soil below to the ground surface. The ground surface is assumed to approximate air temperature. Although air temperature is variable, its average for any period of time can be used in an analysis.

Temperature Gradient

Change in temperature from point to point is called temperature gradient and is designated m in the equation:

$$m = \frac{T_1 - T_2}{d_1 - d_2} \ldots\ldots [1]$$

in which T_1 and T_2 are the temperatures of the soil at depths d_1 and d_2, respectively. The temperature gradient is constant if the soil is homogeneous. Above the frost line the ground will be assumed to be a homogeneous mixture of soil and ice. Below the frost line it is a homogeneous mixture of soil and water. The temperature gradient differs above and below the frost line as the soil-ice and soil-water combinations have different thermal conductivities.

The thermal conductivity of a given material is a constant expressing the quantity of heat that flows in unit time through a unit area of the material having a unit temperature differential over a unit thickness of the material (2). The thermal conductivity will be designated by the symbol k and will be expressed in $\frac{\text{(Btu.)(in.)}}{\text{(hr.)(sq.ft.)(°F.)}}$.

Figures 1A and 1B represent a hypothetical soil that has different thermal conductivities and temperature gradients for a given depth when frozen and unfrozen. Figure 1C shows the temperature gradients above and below the frost line for different thermal conductivities. The temperature gradient below the frost line can be estimated by a formula given by Beskow (3):

$$m = 0.1\,\theta - 3.09 \ldots\ldots [2]$$

in which m is expressed in degrees Fahrenheit per foot and θ is the average yearly ground temperature in degrees Fahrenheit. For most of the northern United States, the ground temperature at 3 ft. is approximately 1°F. greater than the average yearly air temperature. Figure 2 plots Eq. 2 for estimating temperature gradient and can be used to obtain values of m for various values of θ.

Thermal conductivities of various soils with varying moisture contents have been determined experimentally by Kersten (4). The tests showed thermal conductivity to vary as follows:

1. Silt and clay soils, not frozen, moisture content greater than 7 per cent:

$$k = [0.9 \log (M) - 0.2]10^{0.01w} \ldots [3]$$

2. Silt and clay soils, frozen, moisture content greater than 7 per cent:

$$k = 0.01(10)^{0.022w} + 0.085(M)(10)^{0.008w} \ldots [4]$$

3. Sandy soils, not frozen, moisture content greater than 1 per cent:

$$k = [0.7 \log (M) + 0.4]10^{0.01w} \,..\, [5]$$

4. Sandy soils, frozen, moisture content greater than 1 per cent:

$$k = 0.076(10)^{0.013w} + 0.0322(M)(10)^{0.0146w} \,..\, [6]$$

in which k is the thermal conductivity in $\frac{(\text{Btu.})(\text{in.})}{(\text{hr.})(\text{sq.ft.})(°\text{F.})}$, w is the dry density of the soil in pounds per cubic foot and M is the moisture content expressed as a proportion of the dry weight of the soil.

Another property of the soil affecting the depth of the frost line has been called "frost-storing capacity" (3) which will be denoted by H and expressed in British thermal units per cubic foot. This property takes into account the heat of fusion of ice and the heat capacity of the soil and can be expressed as follows:

$$H = (\text{weight of ice per cubic foot of soil})(144) + \frac{T}{2}(w_f)(c_f) \,..\, [7]$$

in which T is the surface temperature in degrees below 32°F. (32°F. minus the average air temperature), c_f is the specific heat of the frozen soil in British thermal units per degree Fahrenheit per pound, and w_f is the density of the frozen soil in pounds per cubic foot. The figure 144 represents the heat of fusion of ice in British thermal units per pound. The frozen soil has a heat capacity equal to $w_f \times c_f$. This product is obtained from the following expression:

$$w_f \times c_f = (w \times s_s \times c_s) + (\text{weight of ice per cubic foot of soil}) \times (s_i \times c_i) \,..\, [8]$$

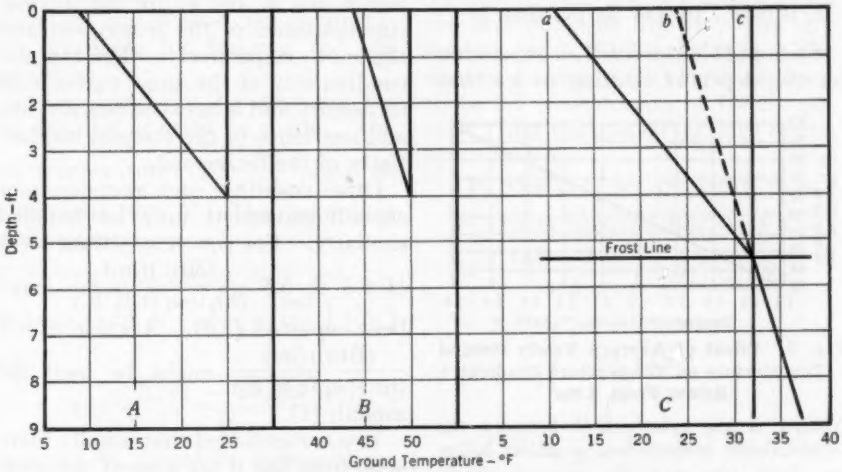

Fig 1. Temperature-Depth Curves for a Given Soil

Graph A *shows the relationship between temperature and depth for the soil when it is frozen. Graph* B *indicates this relationship when the soil is not frozen. Graph* C *shows the extension of the temperature gradient from below the frost line to the ground surface.*

if w is the dry density of the soil in pounds per cubic foot, s_s is the specific gravity of the dry soil, c_s is the specific heat of the dry soil, s_i is the specific gravity of ice and c_i is the specific heat of ice.

The approximate values of these factors are:

s_s is 2.6–2.7 for most soils
s_i is approximately 0.91
c_s is approximately 0.16 Btu. per lb. per deg. F. for all soils (4)
c_i is 0.50 Btu. per lb. per deg. F.

Stefan (3) has derived an expression for the depth of freezing of ice that can be applied to frozen soils to give the depth of the frost line. This expression is:

$$d = \sqrt{\frac{24tTk}{H}} \qquad \text{[9]}$$

if d is the increment of depth to the frost line in inches, t is the period of time in hours and T, k and H have the same values as expressed above.

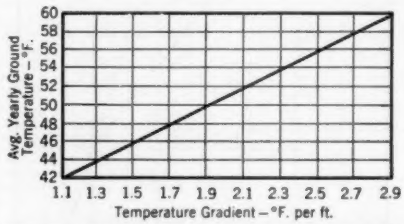

Fig. 2. Effect of Average Yearly Ground Temperature on Temperature Gradient Below Frost Line

Shown is the relationship between the approximate temperature gradient below the frost line and the average yearly ground temperature.

There are some complicating factors which must be considered. The presence of snow affects the depth of the frost line because it has a low coefficient of thermal conductivity and thus acts as an insulator. The snow covering can be neglected when studying critical conditions. If the snow cannot be disregarded, an equivalent depth of frozen soil can be substituted for the depth of the snow. This equivalent depth is:

$$d_e = \frac{k_f}{k_s}(d_s) \qquad \text{[10]}$$

in which d_e is the equivalent depth in inches, d_s is the depth of the snow in inches and k_f and k_s are the thermal conductivities of the frozen soil and the snow, respectively. The thermal conductivity of the snow varies with its density and is between one-seventh and one-tenth of the thermal conductivity of the frozen soil.

Other coverings such as concrete or asphalt pavement may be handled similarly. For concrete, values for k of 5.3 to 6.5 $\frac{\text{(Btu.)(in.)}}{\text{(hr.)(sq.ft.)(°F.)}}$ have been reported (2,5). A value of 4.8 $\frac{\text{(Btu.)(in.)}}{\text{(hr.)(sq.ft.)(°F.)}}$ might be used for asphalt (1).

It was mentioned that usually there is no frost line if the ground temperature is 32°F. The freezing point of the soil moisture may be lower because of adsorption of water by the soil particles. The adsorbed molecules are bound to the soil particles by a strong force which must be overcome before these water molecules can be brought into the lattice of the ice crystal. This adsorption force is almost directly proportional to the surface area of the soil particles for grain sizes down to approximately 0.002 mm. The reduction in freezing temperature from adsorption has no appreciable effect on the depth of the frost line and can therefore be disregarded.

An important factor that should ordinarily not be neglected is the heat conducted to the surface from below the frost line. The flow of heat is proportional to the temperature gradient below the frost line. In Fig. 1*C* the temperature gradient below the frost line is shown extended to the surface by the dotted line. Because of the flow of heat from below, no freezing of the soil will occur until the temperature at the surface is reduced to the value indicated at point *b*. Therefore *ab* is the net temperature available for freezing the soil moisture.

In Eq. 7 and Eq. 9 a correction for the distance *bc* must be made. The net temperature: $T - \frac{md}{12}$ must be substituted for T. The equations then become:

$$H = (\text{weight of ice per cu.ft. soil} \times 144) + (w_f \times c_f)\left(\frac{T}{2} - \frac{md}{24}\right) \quad [7a]$$

and:

$$d = \sqrt{\frac{(24T - 2md)tk}{H}} \quad [9a]$$

Equation 9a cannot be expressed explicitly in terms of d, and Eq. 7a cannot be solved for H until d is known. With a minimum of experience, however, a value of d can be assumed and revised in a second trial or accepted if there is close agreement with the computed value.

An example will illustrate the application of the formulas:

A saturated clay having a dry density of 105 lb. per cu.ft. has a surface temperature of 32°F. on December 10 and is exposed to an average temperature of 14°F. until January 29. There is no appreciable snow during the period, and the average yearly ground temperature at a depth of 3 ft. is 50°F. The problem is, would a service connection 3.0 ft. deep in this soil be in danger of freezing?

The solution to the problem is obtained by first considering conduction of heat from below the frost line, using Eq. 9a:

T = 32°F. − 14°F. = 18°F.
m = 1.91°F. per ft. (from Fig. 2)
d is assumed to be 3.0 ft.
t = 50 days or 1,200 hours.

To determine k, the characteristics of the soil must be known. The dry density, w, is 105 lb. per cu.ft. The specific gravity of the clay is assumed to be 2.7 (true density of 168 lb. per cu.ft.) and the specific gravity of the ice to be 0.91.

The weight of ice per cu.ft. of soil

$$= (\text{voids volume})(\text{density of ice})$$
$$= \left(\frac{168 - 105}{168}\right)(0.91)(62.4)$$
$$= 21.3 \text{ lb. per cu.ft. of soil.}$$

$$M = (100)\left(\frac{\text{wt. of ice}}{\text{wt. of dry soil}}\right)$$
$$= (100)\left(\frac{21.3}{105}\right) = 20.3 \text{ per cent}$$

$$k = 0.01(10)^{0.022w} + 0.085(M)(10)^{0.008w} \quad [4]$$
$$= 0.01(10)^{2.31} + 0.085(20.3)(10)^{0.840}$$
$$= 0.01(204) + 0.085(20.3)(6.91)$$
$$= 2.04 + 11.92$$
$$= 13.96 \text{ (Btu.)(in.)per (hr.)(sq.ft.)(°F.)}$$

$$(w_f)(c_f) = (w \times s_s \times c_s) + (\text{wt. ice per cu. ft. of soil})(s_i \times c_i) \quad [8]$$
$$= (105 \times 2.7 \times 0.16) + (21.3)(0.91 \times 0.50)$$
$$= 45.4 + 9.7 = 55.1 \text{ Btu. per cu.ft. per °F.}$$

$$H = (\text{wt. ice per cu. ft. of soil})(144) + (w_f \times c_f)\left(\frac{T}{2} - \frac{md}{24}\right) \ldots\ldots [7a]$$

$$= (21.3)(144) + (55.1)(9 - 2.78)$$

$$= 3{,}065 + 343 = 3{,}408 \text{ Btu. per cu.ft.}$$

$$(24T - 2md) = (24)(18) - (2)(1.91)(36) = 432 - 137 \doteq 295$$

$$d = \sqrt{\frac{(24T - 2md)tk}{H}} \ldots\ldots\ldots [9a]$$

$$= \sqrt{\frac{(295)(1200)(13.96)}{3408}}$$

$$= \sqrt{1450} = 38.1 \text{ in.} = 3.17 \text{ ft.}$$

A depth of 3.14 ft. is the true depth, and at the assumed depth of 3.0 ft., the service connection was definitely in danger of freezing. The time at which the danger began can be estimated by determining when the frost line reached the 3.0-foot depth of the service connection. Solving Eq. 9a for t:

$$t = \frac{Hd^2}{(24T - 2md)(k)} = \frac{(3408)(36)^2}{(295)(13.96)}$$

$$t = 1{,}074 \text{ hours} = 45 \text{ days or January 24.}$$

If the average temperature from December 10 to January 24 differed appreciably from the 14°F. average from December 10 to January 29, a new calculation could be performed. The effect of disregarding the heat conducted to the surface from below the frost line should be noted. The time at which the frost line was 3.0 ft. deep would be calculated as follows:

$$H = (\text{wt. of ice per cu.ft. of soil})(144) + \frac{T}{2}(w_f)(c_f) \ldots [\text{Eq. } 7]$$

$$= (21.3)(144) + (9)(55.1)$$

$$= 3{,}065 + 496 = 3{,}561 \text{ Btu. per cu.ft.}$$

$$t = \frac{Hd^2}{24(T)(k)} = \frac{(3{,}561)(36)^2}{(24)(18)(13.96)} \ldots [\text{Eq. } 9]$$

$$= 766 \text{ hours} = 32 \text{ days or January 11.}$$

The heat from below the frost line delays the freezing at a 3.0-ft. depth 13 days.

After it has been determined when the frost line will reach the service connection, conventional methods for estimating the additional time required to freeze the water in the pipe can be used (5).

Calculations such as these can be invaluable in designing new systems and reviewing existing ones. It must be emphasized that many uncertainties and approximations are involved that should be correlated with field studies whenever possible. The method is a tool which improves with use. It is based both on basic physical principles and experimental observations.

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Utility Acquisition of Customer-Owned Meters

By Eric F. Johnson

A report prepared by Eric F. Johnson, Asst. Secy., A.W.W.A., to answer the inquiries received by the Association concerning means by which the transfer from customer to utility ownership of meters can best be accomplished. Developed because of the lack of any generally available data on the subject in the literature, this report is based on a small sampling rather than a complete survey of the cities which face and which have solved the problem. Further information on the subject will be welcomed.

METERS are almost always owned by the utilities which furnish service through them. In the gas and electric fields, utility ownership is universally practiced whether the utility itself is publicly or privately owned. In the water works field, however, although utility ownership is most common, there are many communities in which the customers provide and keep title to these important items of utility equipment. Always, of course, the reason for customer ownership is financial. Utilities anxious to take advantage of the closer control of operations made possible by meters have often been unable or unwilling to provide the funds required for their original installation throughout the system. By local ordinance or other means, customers in many localities have thus been forced to provide their own meters, though usually not to test or repair them after installation. However many the supporters of such customer ownership, their number usually decreases rapidly as the age of the original meters increases, and, when the time for replacement arrives, few, if any, utility men want to continue the policy.

The reason why utilities want to own their own meters are numerous, and most of them are as simple as the logic of a butcher's owning his own scales. Utility ownership permits the absolute control of meter size and freedom of testing, repair and replacement necessary for efficient service, but impossible in the handling of other people's property. It permits standardization of type and brand of equipment and thus reduces the spare-parts requirements and the know-how necessary for proper service. It permits simpler record keeping and determination of responsibility for maintenance, repair and replacement. And, perhaps as important as anything else, utility ownership of meters removes one more possible obstacle to good public relations.

Practically all utilities that now use customer-owned meters recognize the disadvantages of their position and would like to take over ownership. They hesitate, not only because of the cost involved, but because of their fears of causing customer distress in effecting the changeover. As the costs of such a transfer will often be offset by increases in revenue resulting from the retirement of a large number of under-registering meters and as customer distress over either property

rights or possibly higher bills can be averted by full explanation of the step, little real reason for worry exists. Certainly the customers should be as interested as the utility in the efficiency made possible and the conservation induced by accurate registration.

A number of cities have successfully accomplished the changeover by a variety of methods, and each has encountered much less resistance than expected. Although each such changeover must be considered as a unique problem, some of the experience of other communities may at least suggest a means of approach.

Outright Appropriation

One of the methods successfully used in the transfer of meter ownership from customer to utility is that of outright appropriation. Three or four years ago, when the Sioux Falls, S.D., water department wanted to take over the 12,000 customer-owned meters in its system, purchase was deemed economically impossible. Approximately three months before the appropriation ordinance was to be adopted, the department sought to enlist public support by presenting explanations of the proposed transaction in the columns of the local newspaper. At the end of its series of articles, the department invited all objectors to the plan to attend a meeting a week before the ordinance was presented for vote. Only 32 customers attended, and, after the ordinance had been discussed, only six or seven still objected. These few "last ditchers" were permitted to keep their meters, with the understanding that the city would be ready to take over at their convenience.

At about the same time, the city of Lamberton, Minn., adopted a similar ordinance. Since most of the meters in use in its system were over-age, they had to be replaced immediately. No great hardship would have been worked, therefore, if all customers had taken the water department up on its offer to turn over the original meter to any customer who wanted it when the city had installed a replacement.

Appropriation under provisions of a similar local ordinance has also been reported at Aurora, Ill.

Voluntary Transfer

More of a selling job to convince customers of the desirability of utility ownership of meters was undertaken at Benton Harbor, Mich., and is carried out on a continuing basis at Kansas City, Mo. The Benton Harbor utility, for example, presented its proposition by sending postcards to all of its 4,200 customers indicating that the city would, in exchange for title to the meter, agree to provide all repair and replacement not occasioned by customer negligence. In making the offer, the water superintendent also pointed out that existing meters had been in service for a number of years and would undoubtedly soon have to be condemned and replaced. By making transfer of title possible through merely signing the postcard announcement of the offer, the utility had no trouble in obtaining a 100-per cent response. Since the transfer, all meters on new services have been installed without cost to the new customer.

A method basically similar to this was found effective, too, by the American Water Works Co., where subsidiaries of that organization took over properties in which the meters were customer-owned. Basing its appeal primarily on the demonstration that service through utility-owned meters was less costly despite a slightly higher

rate schedule than the one applied when the customer owned the meter, these companies were uniformly successful in selling their customers on transfer of title.

The program at Kansas City, Mo., is different in two respects. First, no attempt has been made to take over all meters in one comprehensive drive; but, whenever a meter is tested or repaired by the water department, the customer is advised by letter what his bill for the maintenance will be and how he can avoid this and any future charges for repairs or replacements merely by signing the "enclosed Transfer-of-Ownership form." Second, the original meter for any premises must be purchased and installed at the expense of the owner of the premises; thus the problem of title transfer remains a constant one.

Gradual Change-Over

Another policy which provides for the gradual replacement of customer-owned with utility-owned meters is that of the Batavia, N.Y., Water Department (1). Faced with the fact that almost half the system's 4,300 meters had been in service for more than 30 years and three-quarters of them for more than 20 years, and having encountered "severe resistance and worse public relations" in attempting to "cause" the property owners to purchase new meters, the board of water commissioners instituted a meter service charge of $2.00 per year for all customer-owned meters more than five years old. The service fees collected in this way were then deposited in a fund used for the replacement of overage meters with new ones owned by the utility. For customers who preferred to continue to own their own meters, the board excused the service charge during the first five years of the new meter's use. It is expected that the fund built up from these service charges will permit replacement of all over-age meters in the system and, by this means, effect a change to utility ownership, within ten years.

Less comprehensive in that it does not take into account the age of the meter in applying the service charge, but includes that charge in the regular rate structure, the Pittsburgh, Pa., water department uses the same approach —making itself responsible for servicing customer meters and eventually replacing them with utility-owned equipment. The department does, however, require new customers to provide and install the original meter. And the Pittsburgh plan is now being recommended by the Philadelphia Bureau of Water as a demonstrated success which could be applied in the handling and eventual acquisition of the more than 228,000 customer-owned meters in its system.

Acquisition by Purchase

Although a little more expensive and somewhat more troublesome, undoubterly the most appealing method from a public relations viewpoint is one of the type adopted by the water bureau of the Hartford, Conn., Metropolitan District when it took over the water system of the town of East Hartford approximately ten years ago. To purchase the privately owned meters in the system, the bureau inspected each, made an estimate of what it would have cost the bureau new, depreciated this value on a 25-year straight-line depreciation curve, subtracted from the depreciated value the estimated cost of putting the meter in good condition and then made the owner an offer of that amount. The owner was, of course,

privileged to dispose of the meter in any other way if he saw fit, but he was advised that the utility intended to install its own. The particular formula used for computation at Hartford may not have been the one best suited to the purposes of public relations, but that is less important than the fact that it was logical and equitably applied. Quite obviously it was on that basis that all customers accepted the offer without complaint.

Essentially the same plan as this, in conjunction with a 100-per cent metering program, was recommended to Philadelphia's Bureau of Water by the city's municipal research staff some years ago, with the corollary recommendation that the project be financed by a bond issue to be retired by the income from an increase in rates. The water bureau objected then on the basis of the customer complaints and confusion that would undoubtedly result from more than 288,000 separate transactions and the possible legal entanglements involved. It was at that time that the Pittsburgh plan, mentioned above, was first recommended as being more applicable to a large-scale operation.

Summary

A considerable number of water utilities provide service through customer-owned meters. That this number is as large as 10 in 67 was indicated by a recent survey of meter ownership and maintenance practices (2), which also pointed out that, even in those communities which reported utility ownership, the large commercial, industrial and fireline meters were often customer-owned. Although even the utilities that use customer-owned meters recognize and acknowledge the basic advantage of utility ownership, they hesitate to act because of the cost involved and because of the customer ill will that may be encountered. But in those cities mentioned where transfer of ownership has been undertaken, customer resistance has been practically nonexistent, even in the face of outright appropriation.

Actually the most important consideration in utility acquisition of customer-owned meters seems to be that of public relations, and where utilities have taken the trouble to explain to their customers the reasons, first, for wanting utility ownership and, second, for the particular method of transfer selected, no ill will has been engendered. The public is often actually pleased rather than otherwise with the efficiency gained and the conservation achieved from the change.

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Discussion

By George C. Sopp

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A water utility that does not own, install, operate and maintain its own meters is at a tremendous disadvantage, as it does not have control of one of the most important elements of its system—an element which is directly related to the income derived from its operation. Utilities that do not own

their meters will eventually encounter trouble far more costly than any financial outlay for meter purchase.

As part of its service to customers, a water utility should own, operate and maintain all meters attached to the system. The individual customer is obviously not equipped, either technically or—as his is a passive interest—by inclination, to maintain the water meter adequately. Proper maintenance by the customer to insure efficient meter operation would make his water charge depend directly upon his water use. The utility, however, is rightfully interested in obtaining from each metered service the full amount of revenue to which it is entitled. The best interests of all concerned, therefore, are best served if meters are owned and maintained by the water utility—at its own expense.

Other Utilities

No large utility other than water works permits its customers to own or maintain a device which measures the amount of commodity or service it furnishes them. Repeated studies have shown that such a method of operation is inefficient and costly and is ultimately unsatisfactory both to the customer and the utility.

Utility acquisition of customer-owned water meters can probably be best accomplished in two phases. First, a program of information on "the water works story" should be given to the public through well worded and informative releases by local press and other informational media as part of a planned public relations program. These releases should give the customers and the general public a basic understanding of the community and personal benefits of a good water system and the benefits of utility ownership of water meters.

Second, a simple but fair method of outright purchase from the customers should be instituted by the utility on the basis of the depreciated value of the meters. The price offered to the customer for any meter should not be less than 30–40 per cent of its original cost even though the meters might actually be worth less than that. Such an expenditure would be well worth the public approval that would result. Certainly one of the most important considerations in utility acquisition of customer-owned water meters is that of maintaining good public relations.

Studies on Chlorine Demand Constants

By Douglas Feben and Michael J. Taras

A paper presented on Sept. 20, 1951, at the Michigan Section Meeting, St. Joseph, Mich., by Douglas Feben, Asst. Supt. of Filtration, and Michael J. Taras, Research San. Chemist, Dept. of Water Supply, Detroit, Mich.

AFTER the publication of the first paper (1) in this series, a limited chlorine-demand investigation was undertaken in a number of plants throughout the country to observe whether the chlorine demands of these supplies were an exponential function of the contact time, and, if so, what the magnitude was of the exponential constants. Four reports have been received thus far from widely scattered sections of the nation. Data have been obtained on the Ohio, Missouri and Colorado Rivers, and on two wells in the Long Beach, Calif., area. The chlorine demand curves of all these waters conform to the general exponential pattern noticed in the Detroit metropolitan region.

The test procedure used at these plants adhered essentially to that reported previously for Detroit water (1), varying only in the smaller volumes of water chlorinated and the fewer—usually four—contact times. Another difference of method was the titration of the free chlorine residual by the amperometric method instead of the orthotolidine-arsenite photometric procedure employed in the Detroit experiments. The results obtained by these two methods are known to be comparable if the photometer is properly calibrated.

The data for the raw water are graphically represented in Fig. 1, and the complete data for the raw and filtered waters are given in Table 1. All of the samples yield a straight line when the contact times and chlorine demands were plotted on logarithmic paper. Each line can be equated by the following general mathematical expression:

$$D_t = D_1 t^n \quad \ldots\ldots\ldots [1]$$

in which D_t represents the chlorine consumed, in parts per million, at the end of contact time t, given in hours; D_1 is the amount of chlorine consumed after one hour of contact; and n is the exponential constant characteristic of the given water.

The value of the exponents, which represent the slopes of the respective lines, are of interest, and those of the well waters approach a minimum, both being equal to 0.01, on calculation by the method of least squares. This mathematical process was used in all of the computations reported in this discussion. The low exponents, combined with the relatively high first-hour chlorine demands, show the presence in the samples of such inorganic ions as ammonium nitrogen, sulfide, ferrous ions or any combination of these. The value of the exponents of

the Ohio and Colorado River samples, however, suggest that a substantial proportion of the demand is due to more complex organic agents which exert their demand over a prolonged period. The exponent of the Missouri River water, 0.09, falls between these values and denotes that the water is polluted with inorganic ions such as ammonium or oxidizing ions as well as with more complex organic materials. The closeness of the exponential values between the raw and filtered samples indicates

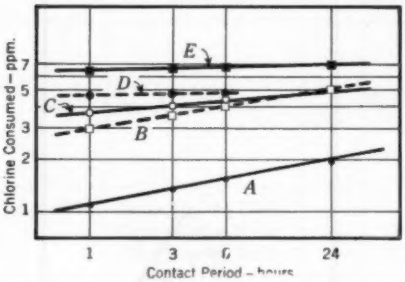

Fig. 1. Chlorine Demand of Natural Waters

Curve A *represents Colorado River water; Curve* B, *Ohio River Water; Curve* C, *Missouri River water; Curve* D, *water from Commission Well at Long Beach, Calif.; and Curve* E, *water from Wise Ranch Well, Long Beach, Calif.*

that the soluble components determine the quality, and largely the quantity, of the demand.

The average of exponents of the Colorado and Ohio River samples equals 0.17, a value comparable to that found in the streams of the Detroit metropolitan area. The low exponential value, 0.01, of the Long Beach well samples also adheres to the ground water pattern in the Greater Detroit region in which the average approximated 0.05. The intermediate exponent of 0.09 for Missouri River water is appreciably lower than the values typical of the surface waters tested in the Detroit area.

This compilation of data is admittedly meager, and, accordingly, must be regarded with considerable caution. The data represent a beginning, however, and it is hoped that further work will be undertaken in other laboratories to ascertain the average chlorine-demand characteristics of the natural sources from which potable waters are drawn.

Nomograph

By the substitution of proper equivalents and the use of suitable mathematical processes, the fundamental Eq. 1 can be developed into a more generally practical form, which will be applicable if the half-hour and one-hour chlorine demands are known. The second equation derived is in the form:

$$D_t = D_1 \left(\frac{D_1}{D_{0.5}}\right)^{3.322 \log t} \quad \ldots [2]$$

in which $D_{0.5}$ represents the chlorine consumed, in parts per million, after 0.5 hours; D_1 is the chlorine consumed after 1.0 hour; and D_t is the chlorine consumed after t hours.

The usefulness of this equation can be further extended by a nomograph (Fig. 2). A quick and sufficiently accurate estimate of the chlorine demand at the end of any contact time t can be made by means of this nomograph from experimental determinations of the chlorine consumption at the end of 0.5 and 1.0 hour. The presence of a free available residual at the end of time t is presumed, and accurate determinations of the residuals at the 0.5- and 1.0-hour contact times are required, as any error in the experi-

mental values will be reflected in the final nomographic reading.

Chlorine Demand and Sewage

As sewage pollution constitutes one of the principal causes of chlorine demand in a surface water, investigation of this aspect of the problem as it related to the chlorination of raw water seemed advisable.

Collaterally, such a program would also yield information on the pollution load contributed by any sanitary sewage effluents to the downstream communities utilizing the Detroit River channel as a raw water source. This aspect of the problem is significant because of the numerous heavy industries in the area which may, and do, introduce wastes into this channel.

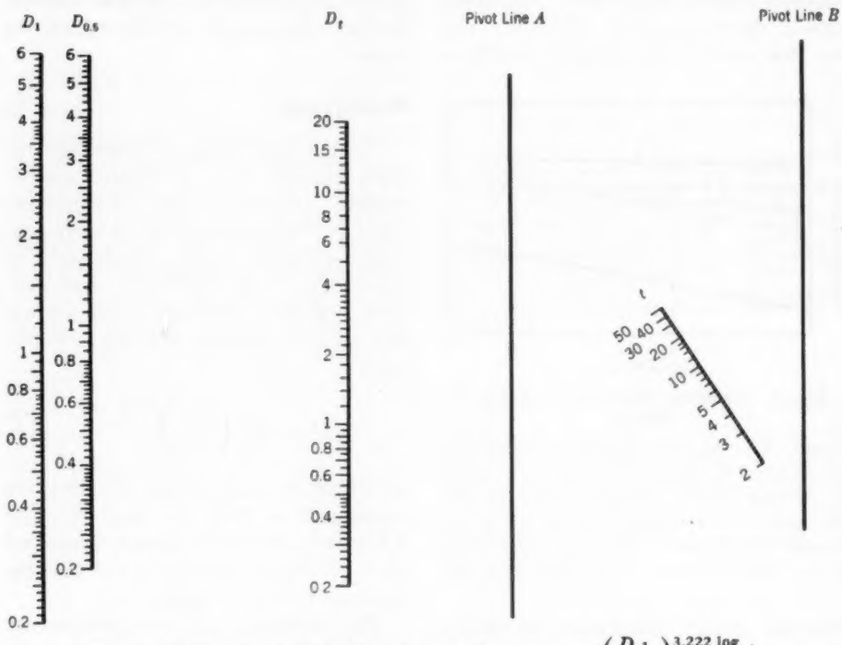

Fig. 2. Nomographic Solution of Equation: $D_t = D_1 \left(\frac{D_1}{D_{0.5}}\right)^{3.222 \log t}$

Align D_1 *with* $D_{0.5}$ *and locate intersecting point on Pivot Line* A. *Pivot on* A *through* t *and locate intersection on* B. *Pivot on* B *through* D_1 *and read* D_t.

The Detroit intake is so located that a particular set of meteorological conditions will cause nearby sewage discharges to contaminate the raw water to an estimated 1.5 per cent by volume. An extended program was therefore instituted to evaluate the effect of raw sewage flows on Detroit raw water.

Experimental Procedure

The raw sewage used in these experiments was an influent sample collected once or twice a week for almost a year at the Detroit sewage treatment plant, at approximately 7:30 A.M. in the morning of each test run. The samples contained varying quantities of

industrial waste as evidenced by the variations of intensity of petroleum odor. Chemical analyses of the raw sewage indicated the presence of much ammonium, albuminoid and total nitrogen in addition to some sulfide and organic sulfur groups. Ferrous iron from pickling liquors was occasionally found in the sewage.

Measured quantities of the well mixed raw sewage were diluted with Detroit raw water to final concentrations of sewage that varied between 0.25 and 1.5 per cent. The pH values of the sewage dilutions before chlorination ranged from 8.0 for the lower sewage concentrations to 7.5 for the higher ones. Most of the experimentation was conducted in the concentration range of 0.5–1.5 per cent. The diluted sewage was then treated with a strong chlorine solution containing between 0.5 and 0.8 mg. chlorine per ml. The dosing was accomplished within three hours of collection of the sample, and was sufficient to yield a free available chlorine residual of 0.3 to 0.8 ppm. after 24 hours of contact.

The chlorinated sewage dilutions were immediately distributed among clean, sterile 250-ml. pyrex solution bottles so that no air gap remained when the glass stoppers were applied to the filled bottles. The bottles were stored in a constant-temperature incubator operated at 74° ± 2°F., a range that represents the average summer temperature of the Detroit River. The one-hour demand has been shown to be directly proportional to the tempera-

TABLE 1

Chlorine-Demand Characteristics of Some Natural Waters

Date	Water Source	Turbidity *ppm.*	Temp. °F.	Cl_2 Dose Applied *ppm.*	Cl_2 Consumed After Given Contact Time—*ppm.*				Computed Constants	
					1.0 hr.	3.0 hr.	6.0 hr.	24 hr.	First Hour Cl_2 Demand *ppm.*	Exponent
Feb. 1950	Long Beach, Calif.									
	Commission Well	0	72	5.01	4.61	4.63	4.69		4.61	0.01
	Wise Ranch Well	0	72	7.20	6.44	6.47	6.57	6.80	6.44	0.01
Jan. 1950	Kansas City, Mo.									
	Missouri R.									
	Raw Water	70	76	5.00	3.64	3.98	4.40	4.85	3.65	0.09
	Filtered Water	0	76	5.00	3.53	3.88	4.15	4.70	3.53	0.09
Feb. 1950	LaVerne, Calif.									
	Colorado, R.									
	Raw Water	0.5	75	2.00	1.10	1.36	1.55	1.92	1.11	0.18
	Filtered Water	0	75	2.00	0.98	1.12	1.25	1.62	0.93	0.16
Mar. 1950	Louisville, Ky.									
	Ohio River									
	Raw Water	125	70	4.98	2.99	3.53	4.02	4.87	2.98	0.16
	Filtered Water	0	70	4.98	2.74	3.85	4.16	4.92	3.01	0.18

ture, but temperature cannot be related to the exponent (1). The selection of this temperature, therefore, resulted in individual observations of the greatest magnitude and minimized experimental error.

Single bottles were removed for the free available residual determination at the end of the first half hour and the first hour. Hourly checks were made for five or six hours thereafter. The final determinations were made after 24 hours of contact time. One bottle was used for each contact period and was promptly discarded.

As in the past, a photometric adaptation of the orthotolidine-arsenite procedure for free available chlorine was employed (1, 2). Occasional checks of this method were made by the amperometric and Palin (3, 4) titrations. Excellent corroboration among all methods was obtained. The Palin titration, however, must be performed with a practiced eye in the presence of sewage concentrations that exceed 1 per cent. The endpoint selected was the discharge of the true blue color rather than the greenish tint which persisted for some time before vanishing. No difficulty was encountered in the titration of Detroit raw and finished waters for free available chlorine by the Palin technique.

Chemical analyses of the unchlorinated sewage dilutions for ammonia and albuminoid nitrogen showed that these two constituents could account for one-half to two-thirds of the immediate 15-minute chlorine demand. This situation was analogous to that of the highly polluted supplies previously examined (2).

Effect on Exponents

As the proportion of sewage materials increases in the raw water, the exponential value of the resulting chlorine demand curves declines. This decrease in the value of the exponent may be attributed to the increasing proportion of the sewage components which quickly consume chlorine. A previous paper (2) listed some of the major chlorine-consuming substances and the relative speed of consumption. The chlorine consumption rate was associated with the numerical magnitude of the exponent; the lower the exponential value, the more rapid was the uptake.

Among the substances which consume chlorine most rapidly were such inorganic ions as ammonia nitrogen, sulfide and ferrous. All three are present in varying quantities in sewage. Of the organic materials, the simple amino acids were generally found to react most readily with chlorine, whereas complex molecules like peptones and proteins were found to react more slowly. To lower the exponential values of such an initial system as a raw water, therefore, introduction of quantities of substances which themselves exhibit lower exponential values is necessary. These added substances will lower the exponential values of the combined system progressively.

Of the three constituents—ammonia nitrogen, sulfide and ferrous ions—the last two are likely to produce the least effect on an aerated surface water. Unless present in considerable quantities as a result of a badly septic condition, small amounts of sulfide, after dilution with raw water, will probably not consume much chlorine. Rapid oxidation of the ferrous ions to the ferric state occurs when sewage concentrations strong in pickling-liquor wastes are added to the raw water. Almost immediately after this type of sewage is mixed with raw water, the

chlorine demand due to the ferrous ion disappears, and the chlorine demand of this diluted sewage compares favorably with that of normal sanitary sewage.

These facts afford comparison between chlorination as practiced at a sewage disposal plant and at a water treatment plant. At the sewage plant, sulfide and ferrous ions are instantly attacked and transformed by the chlorine. In these experiments, sewage samples requiring the largest chlorine dosages at the sewage treatment plant exerted only average chlorine demands when the samples were diluted with raw water. Appreciable amounts of ferrous iron in these sewage samples accounted for the immediate high chlorine demand at the sewage disposal plant—a characteristic of the inorganic oxidizing ions which react with chlorine. High ferrous concentrations, which generated such an extreme chlorine demand at the sewage treatment plant, lost the greatest part of the demand upon dilution with a normally aerated surface raw water of slightly alkaline pH. The ample dissolved oxygen provided by the raw water diluent undoubtedly oxidized the iron quickly to the trivalent state.

In sewage, ammonium nitrogen enters into combination with the chlorine to form chloramines, a reaction that ordinarily governs the extent of the chlorine application to the sewage. Ammonium nitrogen is not easily changed by dilution, and this stability is an important factor in free residual chlorination at a water plant. Much ammonium nitrogen is present in sanitary sewage, and it exerts an appreciable demand at the water treatment plant at which free residual chlorination is practiced. Ammonium and certain amino nitrogen groups consume chlorine in quantities equal to ten times their own weight.

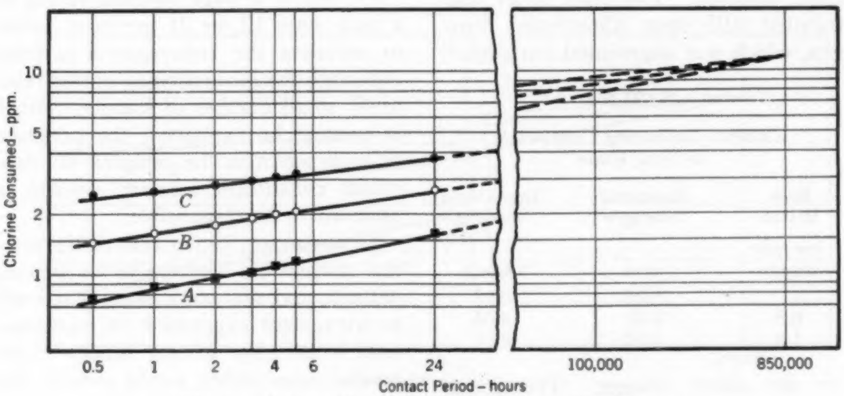

Fig. 3. Intersection Caused by Sewage Dilutions
Curve A *represents raw water; Curve* B, *0.5 per cent sewage; Curve* C, *1.5 per cent sewage.*

Sewage Dilution Equation

Extrapolation of the chlorine-demand lines of the raw and the 0.25-, 0.5-, 1.0- and 1.5-per cent sewage beyond the experimental points showed a tendency for all of the lines to intersect at a

common point. This intersection was characteristic of most sewage samples. A typical example of such an intersection is presented in Fig. 3.

Chemical analysis of the raw water and the sewage dilutions shown in Fig. 3 disclosed the amounts of chlorine-consuming constituents given in Table 2.

A trace (less than 1 ppm.) of sulfide was detected in the original sewage sample but was lost when the 0.5- and 1.5-per cent sewage dilutions were prepared. Similarly, no ferrous or manganous ion could be determined after dilution. The raw water contributed 0.05 ppm. albuminoid nitrogen, which was augmented but slightly by the added sewage. The ammonia nitrogen concentration, however, showed a definite and proportional rise with the increase in sewage application.

TABLE 2

Chlorine-Consuming Constituents in Raw Water

Raw Water	Ammonia Nitrogen	Albuminoid Nitrogen
per cent sewage	*ppm.*	*ppm.*
	0.00	0.05
0.5	0.02	0.06
1.5	0.07	0.07

The mounting concentrations of ammonia nitrogen contributed by the increasing sewage volumes were believed to lower the exponential value of the chlorine-demand lines. The validity of this hypothesis was tested in Detroit raw water by the addition of ammonium nitrogen, an ingredient seldom present under normal circumstances. The experiments showed that the addition of 0.1 and 0.2 ppm. of ammonium nitrogen would produce extrapolated lines (Fig. 4) that would converge at a common point when the chlorine demand and the contact times were plotted logarithmically. Similar lines are produced by increasing dilutions of sewage (Fig. 3).

Although sewage is composed of many substances, the ammonia content is probably a factor in producing the convergence. In view of this finding, and to simplify mathematical analysis of the data, the lines were assumed to converge, and a general equation was developed to relate the known facts.

Of the 57 sewage samples tested in a year, only 12, or 21 per cent, failed to manifest the convergence pattern. Although the inconsistency of this relatively small number of samples cannot at present be explained, the presence of some agent in the complex mixture which constitutes sanitary sewage is assumed to be responsible.

In any event, 79 per cent of the sewage samples did conform to the general pattern, and this conformity lent itself to convenient expression in mathematical form. By solving for an exponential value which would embody the experimental data for the 24-hour period and simultaneously permit the extrapolation of the data to an eventual common point of intersection, a new exponent of the following values was obtained:

$$n = 0.18 - 0.17 \log D_1 \ldots [3]$$

By substituting the new equivalent for n in the general Eq. 1, the following derived expression resulted:

$$D_t = D_1 t^{(0.18-0.17 \log D_1)} \ldots\ldots [4]$$

in which all the symbols have the units previously ascribed.

Use of Eq. 4 permits a satisfactory estimate of the chlorine demand for

any contact time up to 24 hours on the basis of the first-hour demand, as determined in the laboratory. The equation is based on experimental data on sewage dilutions up to 1.5 per cent and presupposes the original addition of sufficient chlorine to yield a free available chlorine residual at the desired contact time.

This equation is at present only of academic interest, but it may sometime be developed as a research tool. An equation of this type might aid, for example, in the study of the progressive pollution of a surface water originally possessing a relatively constant chlorine demand. The first-hour demand is indicative of the quantity and the exponent is a clue to the quality of the demand, prime factors in the deterioration of any stream. The addition of sanitary sewage, moreover, results in a progressive lowering of the exponential value, and this lowering can be expressed by equation under the proper conditions.

Little information has been accumulated to date on sewage concentrations of from 1.5 to 10 per cent by volume. Available data confirm the exponential demand-time pattern.

Summary

Limited information on three surface supplies and two well supplies from widely separated localities duplicate the Detroit pattern of chlorine demand as an exponential function of the contact time.

A nomograph is presented which enables the rapid determination of chlorine demand at any desired contact time when the 0.5- and 1.0-hour demands are known.

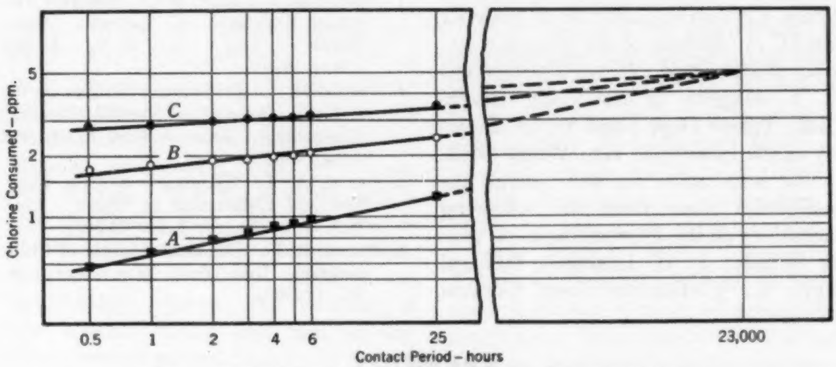

Fig. 4. Influence of Ammonia Nitrogen on Intersection

Curve A *represents raw water; Curve* B, *raw water plus 0.1 ppm. ammonia nitrogen (as NH_4Cl); Curve* C, *raw water plus 0.2 ppm. ammonium nitrogen (as NH_4Cl).*

The chlorine demand-time curves of dilute sewage concentrations are similarly exponential. Addition of up to 1.5 per cent by volume of sanitary raw sewage to Detroit raw water, however, causes the chlorine-demand lines of the sewage dilutions and the raw water to converge at a distant, apparently common, point in time. An identical effect is induced in Detroit raw water by the addition of small amounts of ammonia nitrogen. The presence of ammonia nitrogen in sanitary sewage is probably an important

contributor to this effect in sewage dilutions.

A general equation has been evolved relating the chlorine demand of sewage dilutions in Detroit raw water with contact time.

Acknowledgments

The authors express deep gratitude to the following individuals and their cooperating departments for gathering the experimental data reported in the first section of this paper, in accordance with a procedure furnished them: J. Hinds and W. W. Aultman of the Metropolitan Dist. of Southern California, La Verne, Calif.; M. P. Hatcher and H. A. Nichols of the Kansas City, Mo., Water Dept.; B. S. Thomas and F. T. Higgins of the Long Beach, Calif., Water Dept.; and W. H. Lovejoy of the Louisville, Ky., Water Dept.

The inspiration for this overall investigation came from the following executives of the Detroit Dept. of Water Supply: L. G. Lenhardt, General Mgr.; L. V. Garrity, Asst. General Mgr.; and W. M. Wallace, Supt. of Filtration and Sewage Treatment. Without their continued interest and counsel, this project would never have been undertaken or carried forward.

A particular debt of gratitude is owed to the following staff sanitary chemists for technical assistance in accumulating the data on which much of this paper is based: Michael Garnell, James Hornung, Frank B. McInerny, Thomas Myers and William J. Redman.

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APPENDIX

Derivation of Nomographic Equation

The nomographic Eq. 2 is derived in the following way:

The basic equation is:

$$D_t = D_1 t^n \; \ldots\ldots\ldots [1]$$

in which D_1 is the chlorine demand after one hour of contact, and D_t is the chlorine demand after t hours of contact.

When

$$t = 0.5$$

then $D_{0.5} = D_1 \times 0.5^n$, which, expressed in logarithmic form, becomes:

log. $D_{0.5}$ equals log. D_1 plus n log. 0.5

Then:

$$n = \frac{(\log. D_1 - \log. D_{0.5})}{-\log. 0.5}$$

or:

$$n = \frac{(\log. D_1 - \log. D_{0.5})}{0.30103}$$

or:

$$n = 3.322\,(\log. D_1 - \log. D_{0.5}) \quad \text{(Eq. 5)}$$

Substituting Eq. 5 in Eq. 1:

$$D_t = D_1 t^{3.322\,(\log. D_1 - \log. D_{0.5})}$$

which, expressed in logarithmic form, is:

$$\log. D_t = \log. D_1 + 3.322 \log. t \times (\log. D_1 - \log. D_{0.5})$$

or:

$$D_t = D_1 \left(\frac{D_1}{D_{0.5}}\right)^{3.322 \log. t}$$

Discussion

By H. A. Faber and L. L. Hedgepeth

Respectively, Research Chemist, The Chlorine Inst., Inc., New York, N.Y.; and Technical Consultant, Calco Chemical Div., American Cyanamid Co., Bound Brook, N.J.

Genuine scientists, according to a recent writer, do more than describe facts—they explain them (1). In their paper presented two years ago (2), the authors reported on a basic study which added precision to the prediction of the behavior of chlorine residuals in natural waters. As a result of the study, they concluded that "when a water is chlorinated to give free chlorine residuals, there is a definite mathematical relationship between the demand at one contact period and that at any other contact period."

This new paper is a progress report. More facts are described, and explanation is given in greater detail. The chlorine-demand characteristics of waters from widely separated sources have been found to conform to the general pattern established in the earlier study. The fundamental equation has been further simplified, and its utility has been extended by a nomograph.

The writers consider it important to restate two important limitations which affect the extent to which this new information can be applied at other water treatment plants:

1. A capable technical staff and laboratory facilities of the level required for accurate determination of the chlorine-demand constant of the water must be available at the plant.
2. The chlorine-consuming pollutants in the raw water must be relatively constant in composition and concentration, or the method of control cannot be readily applied.

In the earlier study, the authors (2) demonstrated that temperature has a significant effect upon the chlorine demand. In extending their work to include studies of the Detroit River water with sewage added to it, they employed the constant temperature of 74°F. as the most representative of average Detroit River temperature. Future work might profitably be broadened to include a range of temperature conditions. It is evident also that temperature conditions may be a significant factor in the application of chlorine-demand constants to other waters.

Additional new material is contained in the observation that the extrapolation of the exponential chlorine-demand lines of raw sewage and of dilute sewage-water mixtures showed a tendency for the lines to converge and intersect at an apparent common distant point. By assuming intersection at one point, a considerable simplification of their formula is obtained. They recognize that at this time, this formula is only of academic interest. Although further simplification of the formula is desirable, the basic assumption is so new that the writers believe proof of

the existence of the common point of intersection is needed before this simplification may be considered valid.

Several investigators report that ammonia nitrogen reacts with 9–10 times its weight in chlorine during the free residual chlorination process (3). As ammonia nitrogen is present in appreciable quantities in sanitary sewage, it obviously has an important relation to the chlorine demand of polluted waters. Many polluted streams, however, receive industrial pollutants of other types. If the ammonia content is largely responsible for the converging pattern of the exponential lines, these other pollutants may profoundly affect the validity of applying the simplified equation to studies of such streams.

For example, stream pollution workers are beginning to suspect a difference in the oxidation rate of ammonia in streams, depending upon the source of the ammonia. Some industrial pollutants containing ammonia are oxidized very slowly, in contrast to the ammonia from sewage in the same stream. This difference in the rate of reaction may also be manifested upon chlorination and thus affect the exponential graph. Much more work and caution in the interpretation of data on this matter is indicated.

This continued work by the authors adds to the basic value of their earlier reports. Investigations such as they describe are too rare, as such studies offer the most effective route for the improvement of water sanitation science.

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Rain Increase Projects in Relation to Water Resources

By Irving P. Krick

A paper presented on Apr. 21, 1951, at the Montana Section Meeting, Helena, Mont., by Irving P. Krick, Water Resources Development Corp., Denver, Colo.

ATMOSPHERE explorations first occupied the author's attention eighteen years ago, when he held the meteorology chair at the California Institute of Technology. During World War II, while in military service as a scientific advisor, he directed meteorological research programs. His first direct participation in rain increase projects, however, came in 1946–47, shortly after the early announcement by Irving Langmuir and the General Electric Laboratories of the possibility of modification of clouds by artificial means.

In 1948 the author joined with the rest of the staff of the institute's Meteorology Dept. to organize the American Institute of Aerological Research, a nonprofit private research and consulting organization that undertakes scientific studies in meteorology and allied fields. This research group not only studies the technical data available, but also conducts the actual field operations required for cloud modification.

Pioneer Work

Langmuir's announcement evoked great interest and excitement in a field that is not as new as some believe. In the 1890's a German pioneer patented a method of increasing precipitation by exploding a projectile of solid carbon dioxide (dry ice) within the heart of a cloud. He failed because he lacked information on upper-air temperatures, humidity, pressures and wind direction and speed. His idea was basically the same, however, as that which has resulted in the development of the new science of increasing natural precipitation.

In 1930 a Dutch scientist named Veraart dropped dry ice into a cloud formation from an airplane. He claimed success and sought a government subsidy to continue his experiments. The Dutch weather bureau blocked his bid, and his work was abandoned.

Early experiments carried out under the author's supervision by graduate students at the California Institute of Technology involved the release of dry ice into clouds from aircraft. Further experiments were carried out in the Southern California and Phoenix areas during the two following years.

These pioneer experiments were notable for their effect on subsequent operational methods. Until the early spring of 1949, most experimentation employed the dry-ice–aircraft method. Technical difficulties inherent in the aircraft method, such as the coincidence of good seeding opportunities and poor flying weather, disadvantages of local-

ized seeding in contrast to seeding over a broad geographical area and the lack of adequate control of aircraft operations made it at last apparent that that method for artificial nucleation of clouds was a relatively poor operating technique.

Later Experimental Work

During the winter and spring of 1949, therefore, attention was directed toward the development of ground equipment which would impregnate the air stream with silver iodide crystals. Preliminary results of the ground technique were considerably more optimistic than the aircraft operations. The following year was spent in the developing and testing equipment which, under varying meteorological conditions, would inject silver iodide crystals of the proper size, shape and number into the existing air stream. Research was conducted into mechanical operations and chemical processes used for producing suitable types of fuel.

The American Institute of Aerological Research was concurrently afforded the opportunity to evaluate the results of some experiments that had been undertaken during the summer of 1949 by an unrelated organization in Mexico. Much significant information on evaluation methods and experimental practices was obtained from this study. Studies were resumed in California early in 1950, using the newly developed ground generating equipment, and valuable data for future investigations were obtained.

In March 1950 the Water Resources Development Corp. was formed to contract for large-scale experiments. In June of that year, following a meteorological and economic analysis of the region, the new company contracted for several experiments in the Horse Heaven area of eastern Washington, near the town of Prosser.

The results of these tests again proved encouraging and afforded the company the opportunity to continue the experimentation across a large area of northeast New Mexico and southeast Colorado during July, August and September 1950. The results of these experiments, together with those of more recent operations in Washington, Oregon, California, Arizona, New Mexico and Colorado, are being continuously checked and evaluated by objective statistical methods with the official rainfall figures published by the U.S. Weather Bureau. Similar operations which have been conducted by other organizations throughout the United States are also evaluated.

Current Procedures

During the past year, improvements in equipment and operating techniques have been effected.

The most beneficial effects on rainfall patterns are achieved as a result of preoperational analyses of requirements in the operating areas. The staff of the American Institute of Aerological Research conducts a preliminary survey of the designated area before proceeding with any operations. Such analyses discuss and evaluate the meteorological and local terrain features peculiar to the area, the potential effects of increased rainfall at various times of the year within the area and any possible damages that might result from increased rainfall during any particular season. The final decision for conducting the operations in the area and the suggested months for operation are determined

directly from an appraisal of these preliminary analyses.

Following a decision to conduct cloud seeding, a technical preoperational analysis of the area is prepared for the field supervisor and others directly connected with the operations. This analysis includes a study of past weather patterns influencing the area, the effects of terrain on these patterns and the formulation of the operating method for that particular area and adjacent downwind areas. The field supervisor is thus able to arrange for the proper location of his headquarters and generator sites, one or more of which will be operated depending upon the prevailing storm pattern during each operation. The preoperational analysis also designates the weather-reporting network to be used in analyzing results, establishes methods of evaluation which will improve operations and forecasts the ultimate results of the entire program.

After the technical preoperational analyses have been made, the planning phase is completed by the selection and assignment of personnel, preparation of the field operator's manual, preparation and dispatching of equipment, preparation and establishment of fuel-supply procedures and the establishment of communications between the central office and the field crews.

Field operations are conducted under the supervision of a meteorological engineer whose duties include maintaining contact with the local sponsoring group and the supervision, maintenance, repair and operation of the generating equipment.

Central Control

All operations are centrally controlled through the company's principal meteorological laboratory. In this laboratory, complete, up-to-date weather data are available for all areas of the country. An operational supervisor in the laboratory supplies current weather information and forecasts to the operational areas, varying operations according to the peculiar features of prevailing storms to achieve optimum success. Information from the supervisor is relayed to local field supervisors, who adjust the conduct of the operations as the storms develop.

Evaluation of each cloud seeding operation is accomplished by various standard statistical procedures. Analysis of rainfall and storm data after each storm and after conclusion of each seeding program indicates the effects of artificial nucleation on rainfall patterns. These evaluations are then applied toward the improvement of future operations.

Summary

Successful cloud seeding requires an engineering approach with proper meteorological supervision and careful analysis of all weather factors, with special attention to their relation to artificial nucleation techniques.

Possible damage from cloud seeding at particular times during the year in specific areas and their downwind environs are studied in the preliminary survey analyses. If any possibilities develop for damage, such as would result from additional rainfall during fruit-blooming or harvest periods, operations are rescheduled. Careful examination of the area before operations greatly minimizes the possibility of damage. Coordination of diverse interests through representation on the board of the sponsoring agency also tends to minimize such undesirable effects.

An important result of cloud seeding has been a spreading and smoothing effect upon rainfall patterns, providing more uniform distribution over a wide area, thus minimizing soil erosion. Suppression of hail and rains of heavy intensity within seeded areas appears to be a direct result of this spreading and smoothing effect. The effect is attributed to the impregnation of a large segment of the air stream with silver iodide crystals, which has a more generalized effect, in comparison with the localized results of seeding individual clouds.

The institute has always minimized its claims and has taken the stand that rain cannot be manufactured out of thin air. What can be done is to increase the value of precipitation from a given favorable situation. In this way, new wealth can be brought to the farmer, rancher and water user, and the great risk and gamble to which these people have been subjected in the past can be eliminated.

Ten years from now, cloud seeding will probably be as basic a tool of agriculture as the plow or irrigation. Seeding will, in fact, be an indispensable tool for water users of all types. It is toward that end that the American Institute of Aerological Research continues its work, learning and applying its knowledge for practical purposes, despite criticism of the sort that has been directed toward all scientific pioneers since the beginning of time.

Relationship of Water and Sewage Works Financing

By John W. Cunningham

A paper presented on May 18, 1951, at the Pacific Northwest Section Meeting, Vancouver, B.C., by John W. Cunningham, Cons. Engr., John W. Cunningham & Assoc., Portland, Ore.

OPERATORS in the Pacific Northwest have, in recent years, become increasingly aware of the effects of stream pollution and realize the necessity of cleaning up the region's waters. Along with the rapid population growth, this awareness has led to the large-scale planning and construction of sewers and sewage treatment plants that will cost many millions of dollars. In the past, sewers have generally been financed either through local improvement districts by assessing abutting property or through general ad valorem taxation. For various reasons, objections to these methods of financing have arisen, and, as a substitute, sewer-user service charges have been widely adopted . This practice is not peculiar to the Northwest, and there has been extensive discussion of various methods and enabling acts for allocating and collecting sewer-user service charges.

Sewer-User Service Charge

Much may be said in favor of sewer-user service charges. If account is taken of the relation of the treatment cost to strength of sewage contributed, and if the charges are properly applied, they may be the best and most equitable means of providing the necessary funds. There is no cheap and effective type of sewage meter for individual services, however, and in addition, it is impractical to discontinue sewer service if the customer fails to pay his bills. This condition leads to the first connection with the water industry of the sewer-user service charge. Some relationship exists between the amount of water that goes into a customer's premises and the volume of sewage that comes out. Corrections must be made, of course, for water lost to irrigation, steam, evaporation and the like. Many approximations are involved, but metered water consumption does provide a usable basis for computing a proper sewer-service rate, and this method of calculation has therefore been widely used.

The second connection between sewer service charges and municipal water departments results from the fact that the latter alone have equipment, procedure and personnel trained in billing and collecting for utility service. Moreover, if sewer-service billing can be coupled with water billing, a formidable club to enforce payment of bills is provided—water can be shut off at the premises of the nonpayer.

Sewer-service charges were developed primarily as a method of paying for sewage treatment. Treatment plants usually include trunk and outfall sewers, providing an overall improvement of general benefit to the

community. Such benefits are of the type afforded by schools and other public buildings that have in the past been financed by general obligation bonds paid off by ad valorem taxation. Thus ad valorem taxation for sewer systems is not inherently unfair. Strong opposition, however, from the taxpayer—particularly the influential one—has led to the current switch to sewer-service charges, which are equitable payment methods if properly applied. Common practice has been to compute monthly charges as a proportion of the water bills during the winter non-irrigation months only, prorating these through the year. Industrial users who contribute wastes of unusual strength and character should be given careful consideration and proper rate adjustment, up or down. An essential feature of any sewage rate system is the provision of some board or authority with the power to adjust inequitable rates.

Although the relationship that exists between sewage flow and water consumption extends, with proper adjustments, to the individual water consumer, these adjustments may sometimes be quite substantial. The rate basis and the computation of bills for individual customers should completely separate sewer-service charges from water charges. To save clerical work and postal costs, these two charges may be billed together. A clear distinction, however, should be made between the two charges, so the customer will know exactly how much he is paying for water and how much for sewer service. The practice of consolidating charges into one figure which is billed out as water service is a misrepresentation and is therefore very unfair to the water department. Water rates are reasonable; in fact, they are quite low. Municipal water departments operate practically on a service-at-cost basis. With other commodity costs climbing steadily, the cost of water has been constant—a fact that is appreciated by the public. And any substantial, concealed increase in water charges is detrimental to the good public relations sought by water departments.

Types of Sewer-Service Costs

The sewer service thus far discussed is that of conveying and treating sewage before it is discharged into streams. Although the cost of such service should be kept entirely separate from water costs, through the cycle of collection, accounting and disbursement, the amounts involved are seldom a large proportion of the water bill. Unless very unusual problems and costs arise, 25–50¢ per month from the minimum water consumer and proportionately larger payments from those contributing larger sewage flows will finance treatment plant and outfall sewer construction. The large costs of $1.00–$2.00 monthly which have sometimes been loaded upon small water consumers are not for treatment alone but for branch and lateral sewers and even for complete sewer systems in some of the smaller communities.

The rendering of water service has a flexibility that is not possible with sewer service. Sparsely settled areas can be given adequate domestic water service by small-sized pipe—2-in. or even smaller. Most water departments have some policy under which the consumer must originally pay for unprofitable water-line extensions but receive some form of reimbursement as the area develops and the line becomes

profitable. Ultimately, after a district is quite well developed, larger mains with fire service are provided. With sewage lines, however, no such gradual physical improvement is possible. The minimum practical diameter for a lateral sewer is 8 in., laid at a depth that will provide basement drainage and provided with manholes at regular intervals. All these factors incur construction costs several times as much as the minimum for water-service lines. These costs have handicapped newly developed areas where soil conditions make sewer service a prerequisite for residential construction, but where total values do not justify investment of the considerable sums required.

Payments From Unimproved Property

The fairest and most equitable way to pay for district and lateral sewers is by local improvement district assessments against abutting property that is benefitted. In this way only can costs be charged against vacant lots, which are increased in value by sewers just as much as are occupied ones. Ad valorem taxation does not adequately reach the vacant lots, because many have small assessed valuations. Sewer-service charges cannot be collected from the owners of vacant lots because they receive no tangible service and pay no water bills. For many years, no actual service may be provided to these lots. During this time, the improvement is financed by others, and the vacant-property owners get their sewers without cost. In a community where developed areas are already provided with sewers financed through benefit assessments or by taxation, inequities arise from subsequent construction of district and lateral sewers that is financed through sewer-service charges which are on a uniform basis throughout the community. Such an arrangement forces the older areas to pay twice for district sewers —first for their own and then for a portion of those in the new additions, which do not benefit them at all.

Financing in the Northwest

A large number of Oregon cities have adopted sewer-service charges and have collected them through the local water departments. Most of these charges are moderate, and the money thus collected has been spent for intercepting sewers and sewage-treatment plants. The basic rate in Portland, Ore., is 30 per cent of the water bill, and a capable equalization board has corrected all inequities. Some sewer-service charges in Oregon, collected through the water departments, are as much as \$1.75–\$2.00 per month. This money has been used to pay for complete sewer systems, including laterals. These are exceptionally high rates and are a heavy burden upon water users. The accounting and billing have been kept separated from charges levied by the water departments, and alert water users can thus determine how their money is being spent.

Sewage-user service charges have also been very widely adopted in Washington, and almost all new major sewerage projects are being financed by this method. Available records show one residential rate of \$2.50 per month and several \$2.00 monthly rates. These charges are being made in some smaller communities and are probably for the financing of complete sewer systems, including treatment. Rates of

as much as $1.50 per month are being charged in some areas with existing sewers.

Washington laws, under an act adopted in 1941, permit complete consolidation of water and sewer departments. One argument in favor of this plan is that one superintendent can serve both departments, and overhead costs are thereby reduced. The main argument and real objective, however, is to utilize the credit of the water department to assist in sewerage financing.

Most water departments are well and conservatively managed. Water is a prime necessity of life and people seldom fail to pay their water bills. During the depression years, water departments generally met financial obligations promptly, whereas public bodies that depended on taxation were less able to meet theirs, because many people did not pay their taxes. Water works men are certainly interested in maintaining the good records and good reputations of their departments so that their credit is not impaired.

Consolidation of Water and Sewage Departments

Consolidation of water and sewer departments, therefore, should be effected only with discretion, as such action is potentially dangerous. Before World War II, the water department of one community in eastern Washington was in good financial condition, had reduced its debt and was building a surplus to finance a new filter plant, increased storage and other needed service improvements. War broke out, and a large and continuous population increase developed. The filter plant was constructed but was outgrown. Spreading out of the city increased the need for storage, which, on account of the flat terrain, must be elevated, and is therefore expensive. Main extensions became necessary. During this period, under pressure from bond buyers, the city consolidated its water and sewer departments. A treatment plant was planned but has not yet been built. The water department credit, however, has been used to construct a series of district sewer improvements, including lateral sewers, to serve a series of new additions. The department's indebtedness has been so greatly increased that the financing of needed water works additions will be difficult.

Many water works men have felt the effects—good or bad—of sewage-works financing. The need for extensive sewage improvements undoubtedly exists, and every possible effort should be made to bring them about. For financing and for rate purposes, nevertheless, enough difference exists between sewage and water operations to characterize them as separate entities. Even under consolidated management, no difficulty arises from keeping separate accounts, whereas, if everything is listed under a single heading the results are likely to be damaging to the water department and grossly unfair to water-rate payers.

Disposal of Wastes From Water Purification and Softening Plants

Committee Progress Report

A committee progress report presented on April 30, 1951, at the Annual Conference, Miami, by William W. Aultman, Asst. Director, Dept of Water and Sewers, Miami, Fla.; Chairman, Committee E5–8 —Disposal of Wastes From Water Purification and Softening Plants.

IN September 1946 an A.W.W.A. committee was established to study and report upon methods and practices of disposing of sludge or skimmings from clarification units, sludges from lime or lime-soda plants, brine from zeolite softeners and wash water from filters of all types. Progress reports were made by various members of the committee at the 1947 and 1949 annual conferences (1, 2). An attempt was made to complete the work of the committee, but failure to obtain full data on one aspect of the study prevents this report from being final.

The basic problem has not changed. Disposal of wastes from water purification and softening plants is of increasing concern for several reasons:

1. The country has become pollution conscious, and many states have enacted laws that prohibit dumping such materials into streams or watercourses.
2. The nation is rapidly becoming soft-water conscious, and increasing numbers of people are demanding soft water for domestic and industrial use.
3. A general urban population increase limits the land available in metropolitan areas for the disposal of sludges by ponding and lagooning.

The investigation has been broken down into three rather natural subdivisions. They are disposal of wastes from: [1] filter plants and coagulation basins, [2] cation-exchange (zeolite) softening plants and [3] lime and lime-soda softening plants. This article will indicate only the developments which have been made since the previous progress reports were presented.

Filter and Coagulation Basin Wastes

No further report could be made upon filter plant and coagulation basin wastes. The only information available from the committee is the preliminary report presented in 1947 (1). Upon the completion of a final report on this problem the committee work will be terminated.

Cation-Exchange Softener Wastes

The previous reports on the disposal of brines (1, 2) cover the subject adequately, and therefore, no further study of this problem is contemplated.

Lime and Lime-Soda Softening Plant Wastes

The earlier reports (1, 2) cover the lime problem in quite some detail. Black's summary said, in part (2):

> In addition to ponding or lagooning and disposal in watercourses—these methods of disposal representing present practice in the great majority of plants—four other methods appear to offer attractive possibilities: [1] utilization as a precipitant in primary sewage treatment

if the first plants using that process prove successful; [2] dewatering, drying and pulverizing, as carried out at the plant of the Wright Aeronautical Corp., and disposing of the dried product for a variety of industrial uses; [3] dewatering and calcining in small stationary kilns, of which two types have been described; and [4] for the larger installations, recalcining in rotary kilns.

No further information is available on the utilization of calcium carbonate sludge as a precipitant in primary sewage treatment plants, but additional data should be forthcoming from operation of the Daytona Beach plant. Nor is there any further information about the dewatering and drying of such sludge and disposing of the dried product. Sludge drying is practical, but processing the sludge in this manner depends upon obtaining a permanent market for the dried material, otherwise its disposal is almost as difficult as that of the wet sludge.

Development of stationary kilns capable of economically calcining sludge from small water softening plants is still only in the experimental stage. Lime is produced periodically from sludge in the flash-type calcining system at Marshalltown, Iowa.* Many changes have been made in the design of this plant during its ten years' service, but it is now thought to be operating smoothly. No other plant of this type is in use.

The other type of calciner that it was expected would be applicable to either small- or large-capacity softening plants is the FluoSolids † calciner. A pilot plant of this type has been under test at Lansing, Mich., for about two years. The results of its operation indicate that the system is now sufficiently developed to be safely expanded to a capacity of 50 tons of CaO per day. The fuel efficiency is comparable with that obtained in a long rotary kiln, and the quality of the finished product appears good. It is not certain, however, that the operation of this unit will be economical in the sizes needed by the small softening plants. Its use may depend largely upon its cost or degree of ease of sludge disposal without calcination. The calcining unit for the small plant operator is apparently not yet perfected for commercial availability.

Large-scale sludge calcination with rotary kilns is not new, but it was first used at a water softening plant in the United States at Miami in 1949.‡ The calcining plant functions very satisfactorily, producing a good quality lime at a cost appreciably less than that of commercial lime.

Conclusion

The work of this committee will continue until there is a report to make on the disposal of wastes from filter plants and coagulation basins. The investigations will then be summarized and brought up to date for presentation in a final report.

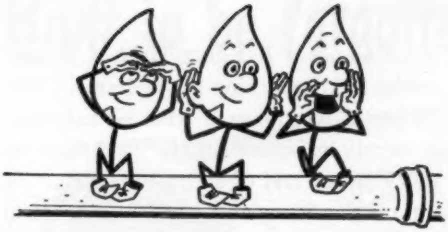
References

1. Am. Water Works Assn. Com. Rpt. Disposal of Water Purification and Softening Plant Wastes. Jour. A.W.W.A., **39**:1211 (Dec. 1947).
2. Am. Water Works Assn. Com. Rpt. Disposal of Softening Plant Wastes. Jour. A.W.W.A., **41**:819 (Sept. 1949).

* Communication from H. V. Pedersen, Supt., Water Works, Marshalltown, Iowa.

† Product of The Dorr Co., Stamford, Conn.

‡ Private communication from C. F. Wertz, Resident Engr., Dept. of Water and Sewers, Miami, Fla.



Percolation and Runoff

"Rainmaking" is already obsolete. Even "weather modification" seems a trifle shaky. And now, with "water resources development" taking over as the term for precipitation incrementation by cumulus nucleation, we detect what must be a slight scent of respectability. What better proof of that ill fate, indeed, than the appearance in the hoity-toitier pages of this very issue of the JOURNAL a straightforward exposition of the current state of the science of cloud-milking and the promise of a full discussion of the subject on the program of next year's Kansas City Conference? We need hardly add that respectability lets us out.

Before we close the door, though, we might take just a little hope from the note that the Interior Department's Bonneville Power Administration has just made a contract with Dr. Irving P. Krick's Water Resources Development Corp. to produce some $59,000 worth of additional rainfall on the Pacific Northwest's Columbia River watershed. Almost as if our old friend Harold Ickes were back thumbing his nose at cohorts in the Commerce Department's Weather Bureau, which has consistently taken a dim view of the efforts of weatherwetters further to foul up its reports. Unfortunately for the cause of disrespectability, the Weather Bureau finds itself in a poor position to start any real reportable rumpus—what with Dr. Krick's 330 million apparently satisfied acres and his backing by the aggressive National Weather Improvement Assn. Even disgruntled fruit growers in the state of Washington unwillingly, if not unwittingly, support Krickedness by blaming rainmakers for a washout of their crop.

Kissing goodby to a month-in, month-out standby like rainmaking—especially right after shutting ourself up on a favorite like dousing—leaves us practically speechless. About the only thing we have left to pick on is the Weather Bureau and even it is getting out of range if the recent report of 88 per cent accuracy of its forecasts is itself accurate. Noting that the report was based on 9,927 observations by 342 volunteer Weather Bureau workers during the past four years, we recall the time that we found P&R absolutely unbiased in its reporting.

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Grasping at straws, water superintendent J. Elliott Hale of Waterville, Me., has developed an easy method of dewatering his hydrants. Not the straws themselves, but the principle of the things is what he has managed to apply to his own advantage merely by simulating the conditions set up by a strong-lunged teen-ager at the upper end of a chocolate soda. A hose, a 15-gal. drum, a check valve on the drum and a truck windshield wiper are the elements employed. By pushing the hose down into the hydrant barrel, attaching the open end to the drum, connecting the drum to the wiper suction and starting the motor of the truck, Hale makes his supersophomore suck the barrel dry. And, to carry the analogy almost too far, he prepares "the gadget" for another "soda" merely by opening the check valve on the drum.

Speaking of ingenuity and suckers, though, the two were well joined in San Diego, Calif., not long ago, when a stranger collected a $5 fine from a local housewife because she did her wash on Wednesday. The housewife made no comment or complaint when the collector explained that he was enforcing a ruling of the "save-our-water" committee to help ease the county water shortage. Not just laundry any more, but the laundress too, is taken in.

ASA's 1942 "Standards on Letter Symbols for Hydraulics" is to be reviewed and revised by a newly reconstituted ASA committee. A tentative decision to include all phases of liquid motion into the committee's scope will require the inclusion of symbols for hydrology and for water hammer. Suggestions and comments from the field are invited and should be addressed to the committee chairman, Dr. J. M. Robertson, P.O. Box 30, State College, Pa.

(Continued on page 4)

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Lt. Col. Raymond J. Karpen shown after his reappointment as chief of the Sanitary Engineering Section, Army Medical Service Corps. Witnesses to the ceremony were Col. Michael J. Blew (left), now with the Army Corps of Engineers, and Paul H. Robbins, executive director of the National Society of Professional Engineers. Col. Karpen served as chief sanitary engineer with the Ninth Air Force during World War II and assumed his present duties in 1948.

Leon Small has retired as water engineer for the Baltimore, Md., Bureau of Water Supply after more than 35 years of service. Beginning as a draftsman in 1911, he became a designing engineer for the Filtration Div. the following year, working on the mechanical and electrical installations for the Montebello filtration plant. After a period of military service during World War I and varied postwar occupations, he returned to the water bureau as assistant mechanical engineer, later becoming mechanical engineer. He was appointed to the post he held for the next 20 years in 1931.

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A simplified practice recommendation for packaging, marking and loading methods for steel products for domestic shipments is in preparation by the Commodity Standards Div., Office of Industry and Commerce of the U.S. Dept. of Commerce. A mailing list is maintained of those who notify the division of their interest in this and similar subjects.

Charles P. McGrath, superintendent of the Water Distribution System, Bureau of Maintenance and Construction, Detroit, Mich., Dept. of Water Supply, retired on September 1 after 40 years of service. He had entered the department as timekeeper in the construction division in 1910, and successively became construction foreman, assistant superintendent of yards and then superintendent of yards. In 1933 the post he was to hold for the next 18 years was created, and he was appointed to fill it.

J. B. Laramy, assistant manager of the Chicago district office of Worthington Pump & Machinery Corp., has been appointed manager of the company's Marketing Research Dept. at the headquarters office of Harrison, N.J. He is succeeded at the Chicago office by J. T. Carroll.

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Claris Allen, assistant chief engineer for the Indianapolis, Ind., Water Co., died on August 30 at his office, following a heart attack. He had been convalescing from a previous attack last year, but had reported feeling better. He had joined the Engineering Dept. of the company in 1930 as assistant engineer, becoming principal assistant in 1944. His promotion to his last post preceded his death by a year.

George W. Booth, who was for 39 years, until his retirement in 1949, the chief engineer of the National Board of Fire Underwriters, died October 2 at his home in Lebanon, N.J. He was 80 years old.

Widely known for his fire prevention work, he was considered an authority on the water supply aspects of fire protection and had directed the engineering survey work of NBFU which resulted in the "Standard Schedule for Grading Cities and Towns of the United States With Reference to Their Fire Defenses and Physical Conditions," and inspections of water supply systems and other agencies for fire protection. Before joining the underwriters organization in 1904, he had been for 11 years an engineer for the Metropolitan Water Board in Massachusetts, making location surveys for dams and aqueducts. In 1945 he was elected an Honorary Member of A.W.W.A.

Joseph F. Bradley, chief engineer of the Department of Water Works, Valparaiso, Ind., died on October 1. Among A.W.W.A.'s senior members, he had joined the Association in February 1921, and became a Life Member earlier this year.

Earle L. Waterman, professor of sanitary engineering and former head of the civil engineering department at the State University of Iowa, died on September 10, at the age of 65, after a long illness. A member of the faculty since 1919, he had retired as department head in 1949, but had continued teaching on a part-time basis. The author of *Elements of Water Supply Engineering,* as well as numerous technical articles, he took an active part in professional and engineering organizations, and had received the Fuller Award in 1945 from the then Missouri Valley Section of A.W.W.A. He served in the Army during World War I, and during the second war directed the engineering science and management war training at the university, training thousands of persons for war work in ten Iowa cities.

A new San Francisco headquarters building for De Laval Steam Turbine Co. has been completed for sales and service activities. The building is located at 160 Folsom St., San Francisco, Calif.

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"Only a stone's throw away" can be pretty distant when it's your water supply that's making like a mirage. But the people of Atlanta, Ga., are throwing stones—200 tons of them, at least—into the Chattahoochee River in the hope of keeping the water at a safe level at the city intake following a two-month drought that has blottered the flow down to the lowest point in ten years. It must have been our friend Paul Weir, general manager of the Atlanta supply, who thought to fight fabulousness with fabulousness and turned to Aesop's thirsty crow for help.

A Fiberglas-reinforced, prefabricated asphaltic membrane lining for irrigation canals has been developed by Owens-Corning Fiberglas Corp. in cooperation with the Bureau of Reclamation. Designed to control seepage and erosion in ditches and canals, but also usable for stock ponds and swimming pools, the lining is said to be strong enough to resist tearing. Installation is accomplished by overexcavating the trench by one or two feet, placing the membrane, and then burying it the one- or two-foot depth, depending upon conditions, beneath the soil. Details may be obtained from the company at Toledo 1, Ohio.

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Name-calling isn't up our alley, but when we heard the other day of the retirement, on October 1, of Charles E. Wilson, we even had to do some name-recalling. Meters, motors, machinery—Charles Ebem, Charles Erwin, Charles Edward—Worthington-Gamon, General Motors, General Electric. Corporation presidents all three, it turned out to be our old friend Charles E. who left his desk after 59 years of service with Worthington to take life a little easier in a consulting capacity on sales problems to Worthington's west coast offices. Certainly the least we can wish is happy motoring and more power to meterman Charley!

To add a pair to that three of a kind, though, we can bring up a couple of Gross of whom we've also heard. Wells, cells—Henry, Harry—Kennebunkport, Rikers Island. Bookmakers both, our friend Henry the diviner called Kenneth Roberts to write his, while Harry the less divine called the cops.

Three of a kind and a pair, but what a full house they'd make!

Thomas C. Kirkwood has been admitted into membership in the firm of A. C. Kirkwood & Associates. He had been connected with the firm since its organization in 1947.

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Criticism of the report of the President's Water Resources Policy Commission (see summary of recommendations in February 1951 JOURNAL, p. 91) was voiced by the National Association of Manufacturers in a report prepared by its Committee on Conservation of Renewable Natural Resources and approved by its Board of Directors. While commending the work of study and compilation performed by the commission, NAM charged that the fundamental assumption underlying all its work was the challengeable one of federal responsibility for the development of water resources on a river-basin scale.

In a vigorous attack on this premise, NAM suggested that individual basin problems involving more than a single state could be handled by the creation of interstate agencies similar to INCODEL and the Interstate Commission on the Potomac River. Intrastate problems could be assigned to state agencies which could regulate the basin development by private capital, if desired. Inherent in the commission's basin-wide federal projects, said NAM, are the "seeds" of socialism.

A discussion of the commission's report was published in the June 1951 JOURNAL (pp. 391, 401, 409 and 414).

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C. T. Butterfield has retired as chief of the Research and Development Branch of the U.S. Public Health Service's Environmental Health Center in Cincinnati. Before assuming that post three years ago he was chief bacteriologist of the center, and 30 of his 36 years of outstanding work in sanitary bacteriology were spent there. Among his accomplishments are listed the proof of the bacterial role in the self-purification of streams, much work on the improvement of methods for the bacteriological examination of water, and important studies of the bactericidal efficiency of free chlorine. He also prepared the bacteriological sections of the U.S.P.H.S. Drinking Water Standards, and is the author of numerous technical papers published in this JOURNAL and elsewhere.

Ernest J. Rowe has retired as superintendent of the Wellsville, N.Y., Water & Light Dept. after 31 years of service to that community, during which he supervised construction of the expanding electric and water plant of that town and otherwise directed their operations. He expects to continue consulting work in the municipal and utility fields.

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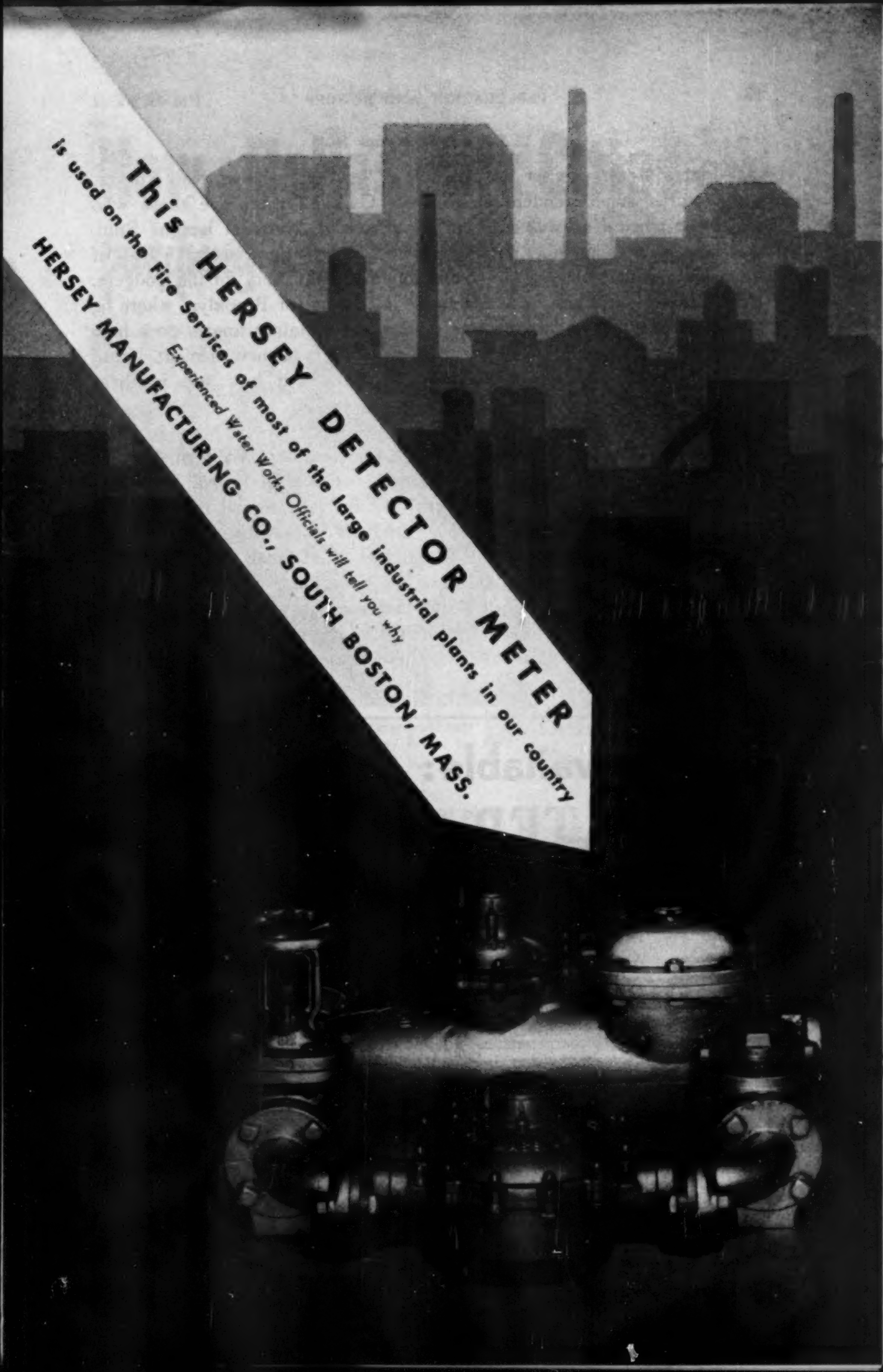


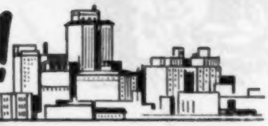
This HERSEY DETECTOR METER
is used on the Fire Services of most of the large industrial plants in our country
Experienced Water Works Officials will tell you why
HERSEY MANUFACTURING CO., SOUTH BOSTON, MASS.

(Continued from page 16)

Just a water pitcher now is new A.W.W.A. member Nap Rucker, water works superintendent at Roswell, Ga., but there are those who remember when Nap was a "Bum"—a Brooklyn National League Bum, that is, who on September 5, 1908, pitched himself into baseball's Hall of Fame by no-hitting the Boston Braves to win a 6–0 victory for the Dodgers. But if Nap thought he was a workhorse in hurling for Brooklyn, where he pitched 336 games in his ten-year tenure, he certainly knows now how much harder is hauling for Roswell, where water is his new element. And his A.W.W.A. membership certainly indicates that he's still in there pitching!

Speaking of halls of fame, though, the Southern California Water Co. gained entry into one maintained by the *Financial World,* when the company received the *World's* "Oscar" for the best annual report in the water works field for the year 1950. In New York City on October 29 to receive the award at an awards banquet, C. P. Harnish, president of the company, was just one jump ahead of the Scranton-Spring Brook Water Service Co. and the New York Water Service Co., which finished second and third respectively in the "best of industry" competition. All three will be featured in *Willing Water* one of these days.

Now...Dallas Park Cities are pumping with Economy!



Portion of main pump room, Park Cities Water Treatment Project. Shown are 13 of the 22 Economy Pumps installed on this project.

View in University Park Booster Station, part of the Park Cities project. These Economy Pumps boost the pressure going to the overhead storage tank, located 5 miles from the treatment plant.

In new Park Cities, Texas, water treatment plant

Economical operation over a period of years was a primary requisite of the pumps for Park Cities Water Treatment Project, Dallas. In selecting pumps, Powell & Powell, consulting engineers, drew up specifications which took into consideration cost of equipment, efficiency of each unit and efficiency of units operating in series, plus rigid structural requirements and refinements of mechanical detail. Under this very exacting evaluation formula, Economy Pumps, designed especially for water works service, supplied by the Lone Star Pump and Machinery Co., were selected on the Dallas County project.

It pays to specify Economy Pumps for water supply. For detailed information and illustrated catalogs write today to Dept. AG-11.

Economy Pumps, Inc.

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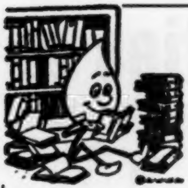


The Reading Meter

Paint Manual. *Bureau of Reclamation, Denver Federal Center, Denver, Colo. (1951) $1.25. Available from bureau office, attention: 841, or from Supt. of Documents, U.S. Government Printing Office, Washington 25, D.C.*

Although intended for Bureau of Reclamation guidance and directed largely toward technical problems of furnishing protective coatings to pipe and other metalwork, this handy manual also contains information on the painting of interior and exterior woodwork, and of concrete, plaster and other surfaces; surface preparation; maintenance of painted surfaces; inspection and sampling; safety; and the care of materials. The result is a manual that has application to many maintenance and installation problems, and that should be found as useful outside the sphere for which it was intended as it undoubtedly is to bureau personnel. Of particular interest to A.W.W.A. members may be the annotated quotations from the Association's specifications for coal-tar enamel coatings, as these supply the bureau's comments and notes on specific sections.

Corrosion: Causes and Prevention. *Frank N. Speller. McGraw-Hill Book Co., Inc., New York (3rd ed., 1951) $10*

The mechanism of corrosion in the ferrous metals and its prevention are considered in this third edition of a standard work. New material added since the 1935 edition includes a chapter on cathodic protection and sections on biological influences. In addition, new experiences with more traditional control measures and fields of study have been included. In discussing the tremendous cost of corrosion, which Uhlig has estimated as almost $6,000,000,000 annually, the author properly observes that "The fact that millions are now being profitably spent every year . . . to mitigate such losses indicates that corrosion is now recognized as a major problem." A welcome symptom of this recognition is the increase in research studies, in knowledge, and in such published reference material as this volume on what might be called the preventive medicine for heavy industry—corrosion control.

(Continued on page 70)

Rhyme on Our Hands

Ballad: Reflections on a Goblet of Water

My hand holds here a goblet, filled
With sparkling water, cold, distilled;
A thousand drops that once was rain
And fed the verdure of the plain;
A thousand drops that kissed the rose
With crystal gems as Morn arose.

My little cup contains all these:
Streams and lakes and mighty seas;
A wispy cloud that hung its pall
Upon some towering mountain wall;
A swirling snowstorm bound in haste
From some frozen arctic waste.

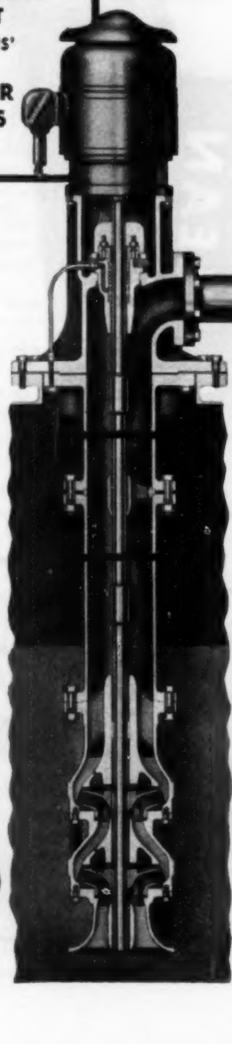
This limpid liquid I have drawn
Began its journey at the dawn
Of God's innate, creative act,
And yet, each drop remains intact,
Unchanged by all the ages past
Or through the forms in which 'twas cast.

This cup can quench a deadly thirst
Or cool the brow that's fever-cursed
But, even so, Death dwelleth here
When storms and floods and shipwrecks rear;
A cup may save, a cup may kill:
It is a liquid versatile.

ENVOY:
Though thrones may reel and kingdoms totter,
Men shall live if they have water;
Men shall live and drink their praise
To God, for water, all their days.

THOMAS R. BRADY

Wabash, Ind.
Sept. 1, 1951



Professional Services
(contd.)

Membership Changes

NEW MEMBERS

Applications received September 1 to September 30, 1951

Ahrens, George C., Mgr., Water Works, Ottumwa, Iowa (Oct. '51)

Albany Dept. of Water & Water Supply, William F. Devane, Comr., 105 City Hall, Albany, N.Y. (Mun. Sv. Sub. Oct. '51) *MP*

Albany County Dept. of Health, Charles A. McLoughlin, 203 City Hall, Albany 7, N.Y. (Corp. M. Oct. '51) *P*

Allen, C. B., *see* Elizabethton (Tenn.) Water Dept.

Atyeo, Reginald G., Supt. of Water, 257 Church St., Belleville, Mich. (Oct. '51)

Baker, C. Elmore, Pres., C. Elmore Baker, Inc., Oklawaha, Fla. (Oct. '51) *M*

Baker, R. E., *see* Leesburg (Fla.)

Berryman, Jerome C., Mgr., Board of Public Works, Poplar Bluff, Mo. (Oct. '51) *M*

Breen, Samuel J., Pres., S. J. Breen Co., Inc., 114–37 Bedell St., Jamaica 4, N.Y. (July '51) *R*

Burns, Vincent Thomas, Jr., San. Engr., The Permutit Co., 330 W. 42nd St., New York 18, N.Y. (Oct. '51) *P*

Caldwell, Donald L., Partner, Caldwell-Rhoads Co., Jacksonville, Ill. (Oct. '51)

Chatham Water Dept., Lester E. Gifford, 77 Main St., Chatham, N.Y. (Mun. Sv. Sub. Oct. '51)

Cirelli, Samuel A., Filter Plant Supervisor, Torresdale Filters, Bureau of Water, State Rd. & Pennypack St., Philadelphia, Pa. (Oct. '51) *M*

Clark, Alvin M., Supt., Lewton-Ft. Sill Water Treatment Plant., Lewton, Okla. (Oct. '51) *MP*

Clifford, Gilbert W., *see* Clifford, Gilbert W., & Assocs., Inc.

Clifford, Gilbert W., & Assocs., Inc., Gilbert W. Clifford, Pres., 101 Westward Dr., Miami Springs, Fla. (Corp. M. Oct. '51) *MPR*

Comarato, Tony C., Water Supt., Box 191, Caldwell, N.J. (Oct. '51) *M*

Contenson, Jean Louis, Vice-Pres. & Gen. Mgr., Pontusco Corp. of Cuba, 31 Nassau St., New York, N.Y. (Oct. '51).

Cooper, George T., *see* Maui County (Hawaii) Waterworks Board

Craig, John D., Supt., Water Dept., Madison, Ga. (July '51)

Crawford, Wilson, Filter Plant Supervisor, Bureau of Water, City Hall Annex, Philadelphia 7, Pa. (Oct. '51) *P*

Devane, William F., *see* Albany (N.Y.) Dept. of Water & Water Supply

Dommes, Sidney Francis, Jr., Public Health Engr., City Health Dept., City Hall, Oakland, Calif. (Oct. '51)

Dowd, Munson W., Asst. Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles, Calif. (Oct. '51) *MR*

Dunbar, Dale R., Partner, Dunbar Drilling & Supply Co., 315 Main St., Delta, Ohio (Oct. '51) *R*

Edens, Emil, Supt., Osgood Water Co., Osgood, Ind. (Oct. '51) *MR*

Elizabethton Water Dept., C. B. Allen, Supt., Elizabethton, Tenn. (Corp. M. Oct. '51) *M*

English, Wayne, Local Mgr., Hoosier Water Co., Bloomfield, Ind. (Oct. '51)

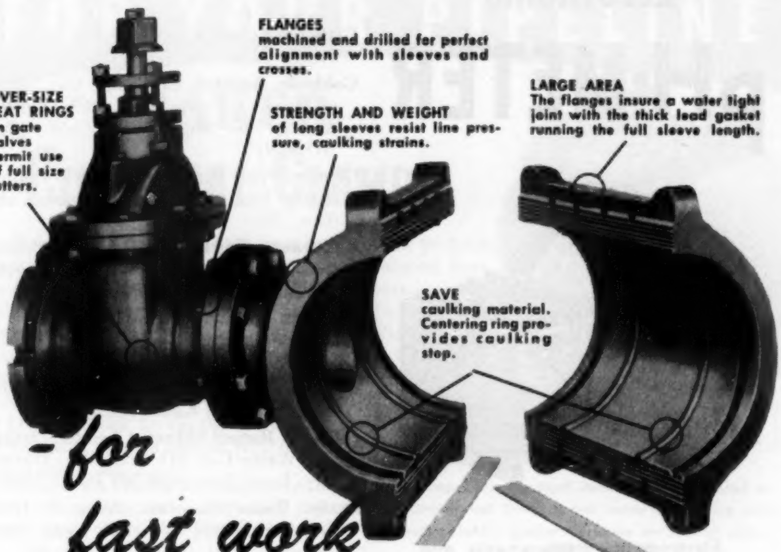
Foley, W. S., Design Engr., Distr. Div., Bureau of Water, 826 City Hall Annex, Philadelphia 7, Pa. (Oct. '51)

Fontaine, Leopold, Asst. Chief Engr., Ministry of Health, Parliament Bldgs., Quebec, Que. (Oct. '51) *MR*

France, Harold H., Asst. Engr., Bureau of Water, City Hall Annex, Philadelphia 7, Pa. (Oct. '51)

(*Continued on page 32*)

They've got Everything!



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18

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(*Continued from page 30*)

Gallagher, John E., Supervisor, Belmont Filter Plant, Bureau of Water, City Hall Annex, Philadelphia 7, Pa. (Oct. '51) *M*

Grifford, Lester E., *see* Chatham (N.Y.) Water Dept.

Goldman, Anathol, San. Eng. Asst., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '51) *MP*

Grimes, Paul, Mgr., North Marin County Water Dist., Box U-I, Novato, Calif. (Oct. '51)

Haagensen, Edward A., Dist. Engr., Infilco Inc., 6404 Hollywood Blvd., Los Angeles 28, Calif. (Oct. '51) *PR*

Harrigan, Paul, Mgr., Courtenay Iron & Brass Foundry, 169 Rothesay Ave., St. John, N.B. (Oct. '51)

Hodson, Nathan, Supt. of Utilities, City Hall, Anthony, Kan. (Oct. '51)

Johnson, Robert Sidney, Chemist, Davenport Water Co., 211 Brady St., Davenport, Iowa (Oct. '51) *P*

Junior Water Co., Inc., Allan F. Kerr, Vice-Pres., 548½ N. Hollywood Way, Burbank, Calif. (Corp. M. July '51)

Kauai County Waterworks Board, David F. Wong, Mgr. & Chief Engr., Box 146, Lihue, Kauai, Hawaii (Mun. Sv. Sub. Oct. '51) *MPR*

Kavanagh, John F., Comptroller, Indiana Gas & Water Co., Inc., 1630 N. Meridian St., Indianapolis 2, Ind. (Oct. '51) *M*

Kerr, Allan F., *see* Junior Water Co., Inc.

Klutts, Alvin W., Chemist & Bacteriologist, City Water & Elec. Dept., Dyersburg, Tenn. (Oct. '51)

Knoedler, Elmer L., Sr. Engr., Sheppard T. Powell, Cons. Chem. Engrs., 330 N. Charles St., Baltimore 1, Md. (Oct. '51) *R*

Kuhn, Orval J., Water Works Supt., Water Treatment Plant, Canton, Ill. (Oct. '51) *MP*

Kunkle, Charles, Jr., Asst. to Gen. Mgr., Johnstown Water Co., Johnstown, Pa. (Oct. '51) *M*

Lane, Benny, *see* Mideke Supply Co.

Lechtenberg, Victor J., Salesman, Municipal Service & Supply, 614 Standard Oil Bldg., Omaha, Neb. (Oct. '51)

(*Continued on page 34*)

(Continued from page 32)

Leesburg, City of, R. E. Baker, Supt. of Public Utilities, Leesburg, Fla. (Mun. Sv. Sub. Oct. '51) *MP*

Lessa, Otto J., Sales Engr., Calgon, Inc., 6445 N. Central Ave., Indianapolis 20, Ind. (Oct. '51) *M*

Le Van, Howard A., Jr., Cons. Engr., 25 N. Front St., Harrisburg, Pa. (Oct. '51)

Likens, Cecil M., Chief Engr., 121 Clark St., Kendallville, Ind. (Oct. '51) *M*

Logan, A. T., Mayor, Trenton, N.B. (Oct. '51)

Lundquist, Howard H., Salesman, Neptune Meter Co., 5228 Brookview Ave., S., Minneapolis, Minn. (Oct. '51) *M*

MacAuley, John D., Sales Engr., Bowser, Inc., 468—9th St., San Francisco, Calif. (Oct. '51) P

MacLean, J. P., Supt. of Public Sewers, Box 58, Antigonish, N.S. (Oct. '51)

Marcotte, B. S., Dist. San. Engr., Provincial Dept. of Health, Amos, Abitibi, Que. (Oct. '51) *MPR*

Martin, Cecil, Supt., Water Works, Hartford, Ky. (Oct. '51)

Maui County Waterworks Board, George T. Cooper, Mgr. & Chief Engr., Bldg. 219, Naska, Kahului, Maui, Hawaii (Corp. M. Oct. '51) *MPR*

McKay, William M., Sr., 162—20th Ave., San Francisco 21, Calif. (Oct. '51)

McLoughlin, Charles A., *see* Albany County (N.Y.) Dept. of Health

Mesa, City of, H. D. Miller, City Engr.-Mgr., 59 N. Macdonald St., Mesa, Ariz. (Corp. M. Oct. '51) *MPR*

Meyer, Paul H., Water Supt., Walla Walla, Wash. (Oct. '51) *MR*

Mideke Supply Co., Benny Lane, Salesman, Pump & Motor Dept., 100 E. Main, Oklahoma City, Okla. (Assoc. M. Oct. '51)

Miller, George A., Water Plant Supt., Sellersburg Water Co., Box 137, Sellersburg, Ind. (Oct. '51) *MP*

Miller, H. D., *see* Mesa (Ariz.)

Moir, W. Stewart, Engr., Wallace & Tiernan, 350 Sorauren Ave., Toronto, Ont. (Oct. '51)

Newton Water Works Board, John O'Leary, Mgr., City Office, Newton, Iowa (Corp. M. Oct. '51)

(Continued on page 36)

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(*Continued from page 34*)

O'Leary, John, *see* Newton (Iowa) Water Works Board

O'Neal, Ben F., San. Engr., State Board of Health, Box 210, Jacksonville, Fla. (Oct. '51)

Pagnotto, Victor Anthony, Mech. Engr., Bureau of Water, 422 Wellesley Rd., Philadelphia 19, Pa. (Oct. '51) *M*

Palm, M. Blaine, San. Engr., U. S. Air Force, R. R. 5, Mt. Pleasant, Iowa (Jr. M. Oct. '51)

Pao-Ching, Liu, *see* Taiwan (China) Water Works Assn.

Pollock, Floro, Supt., Water Works, Kendallville, Ind. (Oct. '51)

Puterbaugh, Paul M., Salesman, Knapp Supply Co., Muncie, Ind. (Oct. '51)

Reader, John D., Asst. Utilities Engr., State Public Utilities Com., State Bldg., San Francisco, Calif. (Oct. '51)

Reed, Garner W., City Engr., Norwich, N.Y. (Oct. '51) *MP*

Rose, Earl, Water Plant Operator, Dept. of Conservation, Brown County State Park, Nashville, Ind. (Oct. '51)

Rothschuh, Emilio, Student, Univ. of Minnesota, 1829 University Ave., S.E., Minneapolis 14, Minn. (Jr. M. Oct. '51)

Rucker, Nap, Supt., City Water Dept., Roswell, Ga. (Oct. '51)

Sayers, G. Howard, Foreman, Water Utility, Merrill, Wis. (Oct. '51) *R*

Sebekos, Thomas G., Eng. Asst., Jamaica Water Supply Co., 161-20—89th Ave., Jamaica, N.Y. (Oct. '51) *MPR*

Seltzer, John Alden, Supt. of Water, 718 Genesee St., Mt. Morris, Mich. (Oct. '51) *P*

Seyler, V. J., Supt., Sewer & Water Com., Marion, Wis. (Oct. '51) *M*

Sharp, Norman N., Machinist-Helper, Bureau of Water, Dept. of Public Works, Philadelphia 7, Pa. (Oct. '51) *P*

Sichina, William J., Treas., Citizens Water Co. of Roscoe, Roscoe, Pa. (Oct. '51) *M*

Smith, Howard A., Repr., Empire Brass Mfg. Co., Ltd., 274 South St., Halifax, N.S. (July '51)

Smith, Sidney B., Westvaco Chem. Div., 405 Lexington Ave., New York 17, N.Y. (July '51) *P*

Soderberg, Arthur L., Sales Engr., Calgon, Inc., 53 W. Jackson Blvd., Chicago 4, Ill. (Oct. '51)

Spacy, Warren Bruce, Asst. Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles, Calif. (Oct. '51) *PR*

Summers, Charles F., Supt., Water Works Dept., Loogootee, Ind. (Oct. '51)

Sutton, William H., Supt., Water Dept., Fairmount, Ind. (Oct. '51) *M*

Taiwan Water Works Assn., Liu Pao-Ching, Pres., Water Works, Chiai, Taiwan, China (Corp. M. Jan. '51) *MPR*

Taylor, Clyde, Operator, Water Works Dept., Loogootee, Inc. (Oct. '51)

Taylor, W. C., Local Mgr., Hoosier Water Co., Mooresville, Ind. (Oct. '51)

Vickerman, Charles Edward, Assoc. Elec. Engr., Bureau of Water, 830 City Hall Annex, Philadelphia 7, Pa. (Oct. '51) *M*

Vollendorf, Ray G., City Engr., Beloit, Kan. (Oct. '51)

Walthall, Junius L., Sales Repr., U.S. Pipe & Foundry Co., 1040 Sedeeva St., Clearwater, Fla. (Oct. '51)

Walton, William C., Hydr. Engr., U.S. Geological Survey, 116 Science Hall, Madison, Wis. (Oct. '51) *R*

Watson, R. K., Engr., J. B. Wilson, Cons. Engr., K. of P. Bldg., Indianapolis, Ind. (Oct. '51)

Wirtschafter, Maurice, Mech. Engr., Bureau of Water, Philadelphia 7, Pa. (Oct. '51) *M*

Wittman, Otto J., Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles, Calif. (Oct. '51) *MR*

Wolfe, Jack L., Engr., The Water Com., Box 420, Greeneville, Tenn. (Oct. '51) *MP*

Wong, David F., *see* Kauai County (Hawaii) Waterworks Board

Yung, Dah-Fong, 2 Lane 12, Tsing Dien St., Ho Ping Tung Rd., Taipeh, Taiwan, China (Jan. '51) *MPR*

Zelinski, John Ward, Graduate Student & Researcher, Dept. of San Eng., Johns Hopkins Univ., 4451—29th St., N.W., Washington 8, D.C. (Oct. '51)

(*Continued on page 38*)

(*Continued from page 36*)

REINSTATEMENTS

Coulson, H. W., Director, Paterson Eng. Co., Ltd., 21 Flambard Rd., Harrow, Middlesex, England (Jan. '46)

Ohio Drilling Co., H. J. Snyder, Vice-Pres., 113—3rd St., N.W., Massillon, Ohio (Assoc. M. June '26)

Snyder, H. J., *see* Ohio Drilling Co.

LOSSES

Deaths

Allen, Claris, Asst. Chief Engr., Indianapolis Water Co., Box 855, 113 Monument Circle, Indianapolis 6, Ind. (Jan. '45) *MR*

Bremser, Martin, Supt., Public Works, 535 S. 6th Ave., West Bend, Wis. (Jan. '43) *M*

Eakin, R. O., Mgr., Water Works, Lodi, Ohio (July '44)

Haydock, Charles, Cons. Engr., 2314 Girard Trust Co. Bldg., Philadelphia 2, Pa. (Feb. '19)

Hughes, Sydney E., Mech. Engr., 5739 Roberts Ave., Oakland 5, Calif. (Apr. '45)

Ranney, Leo, Professional Engr., Box 67, Morro Bay, Calif. (Jan. '50) *R*

Resignations

Boehm, Elmer H., Supt., Public Works, Village Hall, Bellwood, Ill. (Jan. '50) *M*

Collins, J., Engr., Johns-Manville Sales Corp., 205 May Bldg., Charleston, W.Va. (Jan. '49)

Croskey, J. W., Supt. & Supervisor, City Water Dept., Tama, Iowa (Jan. '47)

French, Frank H., Mgr., Factory Insurance Assn., Pacific Regional Office, 465 California St., San Francisco 4, Calif. (July '47)

(*Continued on page 40*)

(*Continued from page 38*)

Hale, Frank F., Pres., Tenneva Water Works, Inc., Box 891, Kingsport, Tenn. (July '48)

Lake City, City of, C. C. Codrington, City Clerk & Auditor, Lake City, Fla. (Munic. Sv. Sub. Oct. '49) *MP*

Lang, Jerome C., Culligan Soft Water Service, Beverly Hills Branch, 1611 S. La Cienega Blvd., Los Angeles 35, Calif. (Jan. '50)

Lobb, John Everett, San Engr. & Director, Div. of General San. State Dept. of Health, Capitol Bldg., Bismarck, N.D. (July '43) *R*

Loudenback, C. I., Sales Engr., Dearborn Chemical Co., 310 S. Michigan Ave., Chicago 4, Ill. (Apr. '42)

Samuel, Ludwig E., Agricultural Attache, Embassy of Israel, 2210 Massachusetts Ave., N.W., Washington, D.C. (Jan. '50)

Schneider, Ernst E., 62 Mequow St., Cedarburg, Wis. (Apr. '49) *MP*

Woolidge, Harold V., Production Mgr., Wallace & Tiernan, Ltd., 109 Evelyn Ave., Toronto, Ont. (Jan. '42)

CHANGES IN ADDRESS

Changes received between September 5 and October 5, 1951

Arruzza, Albert F., 680 Lincoln Dr., Idaho Falls, Idaho (Apr. '49) *M*

Bailey, Robert T., Asst. Engr., Office of City Engr., Welland, Ont. (Jan. '49)

Barnhart, Kenneth, The Permutit Co., 330 W. 42nd St., New York 18, N.Y. (Jan. '49)

Beckman, Wallace J., 1265 Shore Parkway, Brooklyn 14, N.Y. (Apr. '47) *P*

Bickford, Paul N., Box 1281, Oak Harbor, Wash. (Affil. M. Jan. '47)

Bisler, Walter E., Distr., Flexible Under Ground Pipe Cleaning Co., 200 Magee Bldg., Pittsburgh 22, Pa. (Oct. '48) *M*

Booth, Bernard Clement, Virginia Smelting Co., 229 Mount Vernon Ave., Portsmouth, Va. (Oct. '50)

Bowler, Paul D., 209—5th St., Huntington Beach, Calif. (Apr. '47)

Brash, Victor G., Supervisor of Distr., Water Dept., 1810 Highland, Tampa 2, Fla. (July '44)

Burbank, Nathan Clifford, Jr., 808 W. Knapp Ave., Stillwater, Okla. (Oct. '47) *P*

Campbell, Garnet H., Supt., Water Works, 26643 W. Huron Rd., Flat Rock, Mich. (Jan. '45)

Cathodic Servicing Co., T. M. Riseling, 134 Heavy Trafficway, Tulsa, Okla. (Assoc. M. Jan. '50)

Chaney, Howard E., Div. of Industrial Health & Air Pollution, State Health Dept., 2411 N. Charles St., Baltimore 18, Md. (Jan. '44) *P*

Columbia-Southern Chemical Corp., 414 Tower Petroleum Bldg., Dallas, Tex. (Assoc. M. July '38)

Daigneau, A. J., *see* Tilbury (Ont.) Public Utilities Com.

Denize, Clement, Hotel San Luis, Pasaje San Luis, No. 22, Peligro a Pele Ojos, Caracas, Venezuela (July '49) *MP*

Faust, George K., Parsons, Kan. (Apr. '49)

Field, H. L., 117 Riddell St., Greenfield, Mass. (June '29) *MPR*

(*Continued on page 42*)

(*Continued from page 40*)

Frazier, Irvin, 6225 N. Lydell Ave., Milwaukee 11, Wis. (July '44)

Fuller, Jack F., Hersey Mfg. Co., Route 4, Box 84, Kirkland, Wash. (Jan. '49)

Girand, James, Asst. to Pres., New York Water Service Corp., 132 W. 43rd St., New York 18, N.Y. (Jan. '49)

Gordier, Robert L., 3619 E. Fairmont St., Tucson, Ariz. (Jr. M. Apr. '51)

Grundler, Francis E., Engr., Alvord, Burdick & Howson, 1401 Civic Opera Bldg., Chicago 6, Ill. (Jan. '50) *P*

Guyton, William F., White, Guyton & Barnes, 307 W. 12th St., Austin 1, Tex. (Apr. '42) *R*

Harley, Frank E., Civ. Engr., Box 344, Wyckoff, N.J. (Jan. '36)

Harrington, John B., 301 Montrose Dr., South Charleston, W.Va. (July '38) *Director '40–'43. Fuller Award '41.*

Harvill, Clyde R., San. Engr., 6503 Ridgewood Ave., Chevy Chase 15, Md. (Apr. '41) *MPR*

Heath, Donald M., Service Engr., Morton Salt Co., 801 S. 11th St., Lafayette, Ind. (Jan. '50)

Herrera La Riva, Jose, 399 Orange St., Springfield, Mass. (July '49) *MPR*

Hoover, John C., Southwestern Contracting Co., 240 E. 4th Ave., Mesa, Ariz. (Jan. '48)

Janzen, Herman A., State Board of Health, Box 377, Chanute, Kan. (Apr. '46)

Johnson, Charles Ross, 689 Carlston Ave., Oakland 10, Calif. (Oct. '50)

Kaufman, Warren J., Dept. of Eng., San. Eng. Research Project, Univ. of California, Richmond 4, Calif. (July '47)

Keckler, James P., Water Works Engr., 309 Municipal Bldg., Dayton, Ohio (Oct. '48)

Kegebein, John F., Jr., 709 George St., Norristown, Pa. (Apr. '41) *MP*

Kenosha Water Dept., C. R. Nicolazzo, Supt., Kenosha, Wis. (Corp. M. Apr. '37) *MP*

Keyes, Harmon E., Infilco Inc., 2528 E. Monte Vista Dr., Tucson, Ariz. (July '47) *P*

Kolb, T. A., 89 Alexander St., Charleston, S.C. (Apr. '41) *PR*

Lieberman, Morton W., Knappen Tippetts Abbett Co., 9 Jaffa Tel-Aviv Rd., Tel Aviv, Israel (Apr. '51) *MPR*

Luce, Arthur T., New York Water Service Corp., 132 W. 43rd St., New York 18, N.Y. (Apr. '19) *M*

Luthin, John C., Mgr. & Engr., Monterey Bay Water Co., 1113 Laurent St., Santa Cruz, Calif. (Jan. '40) *M*

Malony, George A., 402 Fuller Ave., Council Bluffs, Iowa (Oct. '49)

Mannes, C. O., Civ. Engr., c/o City Engr., Kelso, Wash. (Apr. '48) *P*

Martin, H. Fred, Infilco Inc., 3803 Main St., Houston 2, Tex. (Jan. '46) *MPR*

Martin, Phil J., Jr., City Water Supt., 69 N. Meyer St., Tucson, Ariz. (Mar. '31)

McGauhey, P. H., Univ. of California, Richmond Field Station, Richmond, Calif. (July '38) *P*

McWaters, R. J., *see* Metallizing Engineering Co., Inc.

Metallizing Engineering Co., Inc., R. J. McWaters, Sales Mgr., 38-14—30th St., Long Island City 1, N.Y. (Assoc. M. July '51)

Miller, Leonard William, Sales Repr., American Cyanamid Co., 3505 N. Kimball Ave., Chicago 80, Ill. (Jan. '51) *P*

Moore, Charles E., Engr. of Constr., Water Dept., 2419 Avenham Ave., S.W., Roanoke 14, Va. (Oct. '23) *Director '46–'49. Fuller Award '48. M*

Morton Salt Co., Thomas E. Driskell, 120 S. La Salle St., Chicago, Ill. (Assoc. M. Oct. '37)

Nicolazzo, C. R., *see* Kenosha (Wis.) Water Dept.

Orgain, Holmes, San. Engr., State Dept. of Health, 620 Woodborune Ave., Baltimore 12, Md. (July '51)

Peirce, Millard O., Jr., New York Water Service Corp., 132 W. 43rd St., New York 18, N.Y. (July '48) *R*

Perliter, Simon, Perliter & Soring, 448 S. Hill St., Los Angeles 13, Calif. (Jan. '49) *P*

Peterson, C. J., 8742 Sylmar Ave., Van Nuys, Calif. (July '46) *PR*

Peterson, Thoburn F., 119 William St., Watertown, N.Y. (Jan. '50)

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(Continued from page 42)

Richardson, Allyn St. Clair, c/o H. Y. Richardson, 212 E. 20th St., North Vancouver, B.C. (Jan. '46) *PR*

Roden, Carl Christian, Sales Engr., Builders-Pacific, Inc., 9358 Culver Blvd., Culver City, Calif. (Apr. '50) *P*

Rosenthal, Richard L., Pres., New York Water Service Corp., 132 W. 43rd St., New York 18, N.Y. (Oct. '48) *M*

Ruston, G. H., Mgr., City Water Dept., 20 Salem Ave., S.E., Roanoke, Va. (Apr. '40) *M*

Sanchez, Rafael Giquel, Calle 27 No. 117 entre M y N, Vedado, Havana, Cuba (July '38)

Sherman Machine & Iron Works, 2–26 E. Main St., Oklahoma City 2, Okla. (Assoc. M. Jan. '40)

Smith, Marlo E., 3212 Hennepin Ave., S., Minneapolis, Minn. (Jan. '49)

Sonderegger, A. L., Cons. Engr., 448 S. Hill St., Los Angeles 13, Calif. (Mar. '33) *MPR*

Stephens, Felton, Route 1, Box 11, Austin, Tex. (Jan. '44) *M*

Svaty, Karl J., City Engr., 303 Evans, Garden City, Kan. (Apr. '48) *MP*

Taylor, Orville W., Gen. Foreman of Utilities, B. F. Goodrich Chem. Co., R. R. 1, Box 260B, Nitro, W. Va. (Oct. '46)

Thomas, Ralph M., 348 Lexington St., Watertown, Mass. (Oct. '46) *MPR*

Tilbury Public Utilities Com., A. J. Daigneau, Tilbury, Ont. (Corp. M. Apr. '34)

Unger, Gilbert C., Jr., 805 N Beaux Arts Apartment Hotel, 310 E. 44th St., New York, N.Y. (Jan. '50) *M*

Van Doren, Loyal M., Servis & Van Doren, Cons. Engrs., 409 Crawford Bldg., Topeka, Kan. (Apr. '46) *PR*

Walsh, Raymond, Water Pollution Control Engr., Regional Water Pollution Control Board, Bank of America Bldg., San Luis Obispo, Calif. (Jan. '50) *MP*

Warren, Herbert Clifton, 310 Amelia Ave., Glendora, Calif. (Mar. '27) *MR*

Whiteside, William Minder, Sales Engr., Hersey Mfg. Co., 1400 W. Siwanoy Dr., Alhambra, Calif. (Apr. '50) *MPR*

Zelley, John W., Public Health Engr., State Dept. of Health, Columbus Rd., Burlington, N.J. (Affil. M. Jan. '39) *P*

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CHEMICAL ANALYSIS

Sensitizing the 4-Aminoantipyrine Reaction With Phenolic Materials for Use in Water and Waste Analysis. M. B. Ettinger, C. C. Ruchhoft & R. J. Lishka. *Unpublished paper presented at meeting of Div. of Water Sewage & Sanitation Chemistry, Am. Chem. Soc. (Sept. '50).* Because of simplicity and speed, use of 4-aminoantipyrine would afford desirable technique for trace-quant. detection of phenols in surface waters and industrial wastes. Starting with method described by Martin and using phenol as the test compd., it was found that reaction products could be extracted by a number of chlorinated solvents. Chloroform was apparently best adapted for anal. use. Complete extraction obtained using three serial extractions. Extraction of phenol color with chloroform had many effects. Color of the chloroform-extracted dye was yellow rather than the red shown by the aq. soln. Potassium ferricyanide used as an alk. oxidant in the reaction not extracted by the chloroform. Strong yellow background color of the aq. reaction mixture was thus elimd. Using phenol as test chem., the effect of various reagent concns. and reaction conditions studied to det. conditions for max. reaction stability. Intensity and shape of absorption curves of reaction products extracted with chloroform have been detd. for phenol, *o*-cresol, *m*-cresol, 1-naphthol, 1-chlorophenol, 4-chlorophenol and 5-hydroxy-1,3-dimethylbenzene. Under controlled conditions, these chems. apparently react linearly to very low concns. For phenol, reaction is sensitive to approx. 0.01 ppm. with a 300-ml. sample and 0.002–0.003 ppm. with a 1-l. sample. Many commoner phenols yield a reaction product with an absorption max. in the chloroform extract at a wave length of 450 to 460 mμ. Quant. response of individual phenols to test highly varied, limiting the interpretation which may be placed on results of anals. applied to surface water or wastes containing mixtures of phenols. —*P.H.E.A.*

Ground Water Resources and Their Conservation: Ground Water Provinces of the United States: Provinces G, H, and I. Johnson Natl. Drillers Jour. **23**:1 (Mar.–Apr. '51). These three provinces not large, but constitute principal ground water supply source for area they cover. Province G, known as Wis. Paleozic province, covers southwest quarter of Wis. and a small area in the northwest corner of Ill. Most ground water supplies obtained from wells of moderate depth in the Cambrian or Ordovician sandstone or limestone. These wells usually yield ample supplies of hard but otherwise good water. In many Paleozoic aquifiers. Area devoid of glacial drift except in valleys where there are water-bearing outwash gravels. Province H, known as the Superior Drift-Crystalline province, covers a large area in the northern part of Wisconsin and about two-thirds of the northern part of Minnesota. Satisfactory supplies are obtained in most

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parts from the glacial drift. Where the drift is thin water supplies are generally scarce, because the crystalline pre-Cambrian rocks lying near the surface yield very little water, if any. The drift waters range from soft waters low in minerals in Wisconsin to highly mineralized waters, some of them unfit for use in the western and especially the northwestern part of the province. Province I, known as the Dakota Drift-Cretaceous province, extends over the eastern half of North and South Dakota, a small area in the northwest corner of Iowa, and a narrow V-shaped strip in the east-central part of Nebraska. Two important sources of ground water are available in the area, the glacial drift and the Dakota sandstone. The waters from the Dakota sandstone as a whole are good though highly mineralized in places. Details are given concerning the water-bearing formations of specific sections of Provinces G, H, and I.—*P.H.E.A.*

The Problem of the Chemical Classification of Natural Waters. O. A. Alekin. Voprosy Gidrokhim (U.S.S.R.), **32**:25 ('46). Discusses: [1] some criteria used in some existing systems of classification and [2] proposal of new classification system. With regard to existent systems, A. names five different methods: [1] classifications based on salts occurring in waters (such systems are based on hypothetical salt forms and are easily employed in brine study); [2] classifications on basis of some special factor giving waters characteristic properties (presence of H_2S, Fe, Ra, Li, BO_2^-; such classifications cover only small part of ground water); [3] classifications based on extent of mineralization; [4] classifications based on presence of one or several predominant components; and [5] classifications based on relationships between ions.

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Palmer system given as example of these. New system proposed by A. is based on following principles: [1] awkward systems are avoided (thus proposed system does not establish universal classification); [2] for most part, chief attention directed toward classifying slightly and moderately mineralized waters. For strongly mineralized waters, there are to be separate classifications; [3] there is combination of the principle of classification on basis of predominating ions with that of differentiation with regard to relation between ions; [4] brief symbolization; and [5] classification to be related to landscape and to specific geol. conditions. According to proposed scheme, waters divided into three general classes on the basis of no. of equivs. of the chief anion, the SO_4^{--} class, the HCO_3^- class, and the Cl^- class. Each class then divided into three groups based upon no. of equivs. of the predominating cation; for example, Ca^{++}, Mg^{++} or $Na^+ + K^+$. In turn, each group sepd. into three types, detd. by relationships between ions. In detg. types, criteria were those of general hardness ($H = Ca^{++} + Mg^{++}$), and alky. ($Alk = (HCO_3^-) + 2(CO_3^{--})$). For brevity, system of indexing used. HCO_3^- class designated by C, the SO_4^{--} by S, and the Cl^- by Cl. Groups designated by chem. symbols as powers of class symbol. Types given by Roman nos. as subscripts to the class symbol. As an example of an index, there might be a water having the index, C^{Ca}_{III}. 30 references.—*C. A.*

Aggressiveness (of Potable Water) for Lime According to Franquin and Marecaux. Carlos Candido Coutinho & J. J. Antunes Gon-

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CALVES. Anales bromatol. (Spain) 1:235 ('49). For detn. of aggressiveness, det. pH, combined CO_2, free CO_2, Ca and residue of evapn. at 150° by the known methods. Plot sum of bicarbonate CO_2 and free CO_2 as mm./l. on abscissa. Intersection of pH curve of water with ordinate corresponding to values indicated above gives "representative point" of water. This point lies either below soly. curve of $CaCO_3$ (aggressive water), above curve (incrustant water), or coincides with curve (water in equil.). For aggressive water, pH and aggressive CO_2 vary with correction method applied: [1] aeration, [2] addn. of $Ca(OH)_2$ or [3] addn. of marble. Method 1 reduces free and thus total of free and bicarbonate CO_2 content and increases pH. Representative point displaced parallel to abscissa until it reaches $CaCO_3$ soly. curve. The pH curve passing through this point gives pH water will have when all aggressive CO_2 is elimd. Distance on abscissa between representative point of water and equil. curve gives aggressive CO_2, and distance between latter curve and HCO_3^- curve the equil. CO_2. When Method 2 is used, representative point of water is detd. as indicated above, this point joining the HCO_3^- curve by a straight line forming a 45° angle with abscissa. Aggressive CO_2 given by straight line joining the representative point of soly. curve of $CaCO_3$, and equil. CO_2 by the line joining curve with HCO_3^- curve. Place of intersection of soly. curve with pH curve gives pH required by water after treatment with $Ca(OH)_2$. With Method 3, aggressive CO_2 content given by difference of ordinate from representative point and intersection of soly. curve and CO_2 at equil., by difference of ordinate of latter point and point of interception with HCO_3^- curve.—*C.A.*

Change of the Content of Oxygen in Water Samples Under Different

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Conditions of Storage. O. A. ALEKIN & P. P. VORONKOV. Vopросy Gidrokhim (U.S.S.R.), **32**:98 ('46). Study of effect of different conditions of storage water samples on their O content. Chief problems involved were preservatives to be used and whether to store samples under acid or alk. conditions. For exptl. work, water samples were taken from the surface of the Neva River. Expts. made to det.: [1] final quant. of O after storage of samples in ordinary and hermetically sealed flasks; [2] change in O content in samples of distd. water kept in the air and beneath water; [3] O losses in samples of distd. water stored at increased temps. in comparison with the temps. *in situ;* [4] change of O content in Neva River water samples during storage in unpreserved and preserved condition at *in situ* temps. and at 18–20°; [5] influence of preservatives on microörganisms; [6] activity of $HgCl_2$ soln. as preservative; [7] O change during storage of sample in acid and alk. media. O contents were detd. by Winkler method. Preservatives tried were xylene, chloroform and $HgCl_2$. Best of these was $HgCl_2$. Loss of unfixed O from water samples occurs because of O escape to the atm. and biol. consumption of O by microörganisms. O losses to atm. occurred only when samples were stored at temps. higher than the temps. at which taken. Samples should be stored under alk. conditions if O content is to be detd. by Winkler method. Tables of data obtained from expts. included. —*C.A.*

Change of the Chemical Composition of Water Samples During Their Storage. E. N. CHERNOVSKAYA. Voprosy Gidrokhim (U.S.S.R.), **32**: 87 ('46). Report of lab. studies on effects that different preservatives have on the change of chem. compn. of water samples during storage. Preservatives tested were chloroform, ether, xylene, H_2SO_4, and $HgCl_2$. For preservation of HCO_3^- author used CO_2. Following component studied: HCO_3^-, pH, free CO_2, NO_3^-, NO_2^- and oxidizability. Periodical anals. for these components made at following intervals: [1] directly *in situ* or in lab., [2] after 6 hr., [3] after 1 day, [4] after 3 days, [5] after 10 days, [6] after 1 mo. and [7] after 3 mo. Was sufficient to det. pH to an accuracy of 0.1. Was also necessary to carry out detn. for free CO_2 *in situ*, since a change in its content occurs in period of first 6 hr. after taking sample. Substantial changes of NO_2^- and NO_3^- content and oxidizability occurred after first 3 days of storage. And addn. of preservative did not lead to complete preservation of sample during further storage. A change in water compn. takes place even when microbiol. anal. indicates complete sterility of sample. Best preserving action shown by H_2SO_4, $HgCl_2$ and sometimes xylene. H_2SO_4 interfered with detn. of nitrites, sulfates and alkalinity, and xylene interfered with detn. of oxidizability. $HgCl_2$ interfered with detn. of cations and chlorine. There are extensive tables representing these lab. investigations.—*C.A.*

Use of Bathometers of the Simplest Construction for Taking Water Samples for Chemical Analysis. O. A. ALEKIN. Voprosy Gidrokhim (U.S.S.R.), **32**:117 ('46). Critical evaluation of characteristics of some bathometers of simplest arrangement. Chief advantages seem to be: [1] low cost, [2] simplicity of arrangement, [3] possibility of using ordinary thermometers in them. Errors in observations involving use of these bathometers usually arise from: [1] contact of water with air in bathometer and [2] suction action of bathometer during filling with water. Especially when water sample is to be analyzed for gases, does contact of water with

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air in bathometer introduce error. Requirements set forth for bathometer are: it should: [1] elim. possibility of contact of water with air and should not produce a suction action, [2] "cut" water during immersion, [3] not turn over, [4] be short or have several stopcocks on its frame, [5] have accurate deep-water thermometer and [6] possess portability and simplicity of operation. Two tables included. One table gives a comparison of results obtained by four types of bathometer at different depths and temps. Second table gives results obtained with Voronkov bathometer at two depths and during fall and summer seasons. Results expressed in mg. of O_2 per l. of water.—*C.A.*

Modification of Sanchis' Method for the Determination of Fluoride in Drinking Water. JOHANNA P. BOONSTRA. Rec. Trav. Chim. (Neth.), **70**:325 (1951). By changing Zr-alizarin ratio to 1:6 sensitivity of method increased approx. 6 times, making it suitable for use with photoelec. colorimeter. Dissolve 0.644 g. $ZrOCl_2 \cdot 8H_2O$ in 500 ml. H_2O (*a*) and 4.104 Alizarin Red-S in 3,000 ml. H_2O (*b*). Add 150 ml. *b* slowly with shaking to 25 ml. *a* and make up to 250 ml. with 1:1 mixt. of 4*N* H_2SO_4 and 4*N* HCl and let stand overnight. The NaF std. prepd. by dissolving 2.21 g. in 1 l. and dilg. 10 ml. of this to 1,000 ml. (1 ml. = 0.01 mg. F). Calibration curve prepd. by transferring aliquots contg. 0, 0.025, 0.050, 0.075, 0.100 and 0.200 mg. F to 100-ml. flasks, adding exactly 10 ml. of Zr-alizarin (1:6) reagent and making up to mark with water. Solns. transferred to 250-ml. Erlenmeyer flasks, rapidly heated to boiling but not boiled, and set aside to cool. After 4 hr. the extinctions are measured at 530 mμ, a Coleman junior spectrophotometer being used. To 10 ml. of reagent, water to be tested is added to make the vol. 100 ml. and treated as detailed. Amts. of F of 0.50 to 1.00 mg./l. recovered quantitatively with addn. of phosphate varying from 0.50 to 4.00 mg. P_2O_5 per l. Smallest detectable amt. of F in drinking water with method was 50 γ per l.—*C.A.*

The Determination of Radon and Radium in Water. R. B. JACOBI. J. Chem. Soc., Supplement 2 (Br.), S314–S18 ('49). Scheme described for Rn and Ra anal. devised as compromise between opposing aims of simplicity and convenience of working and high sensitivity of measurement. Latter arose from expectation that waters to be anald. would generally contain appreciably less than a micro γ of Ra per l., and, as not desired to handle water samples of a vol. greater than 1–2 l., equip. required which would measure activities of 0.1 $\mu\mu$curie. Exptl. procedure involves the sepn. of Rn dissolved in H_2O sample and its transference to ionization chamber for measurement, and concn. of Ra into soln. of small bulk, from which Rn may be allowed to accumulate, Ra being estd. by measuring amt. of Rn so obtained—*C.A.*

Use of Complexones in Chemical Analysis. VI. Colorimetric Determination of Chromium. R. PRIBIL & J. KLUBALOVA. Coll. Trav. chim. Tchecosl. (Czech.), **15**:42 ('50). Colorimetric method for deteg. chromium based on formation of purple-red complex by boiling trivalent chromium with ethylenediamine tetraacetic acid in neutral or weakly alk. soln. Color may be measured in colorimeter or spectrophotometer using wave length of 550 mμ. Method suitable for detg. chromium concns. between 0.1 and 8 mg. per 100 ml. of soln. Cobalt, iron, nickel, and copper also form colored complexes with reagent and, if present, must be removed by pptn. as hydroxides in alk. soln. and in presence of hydrogen peroxide. This treatment converts trivalent chromium to chro-

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mate which is best reduced by the complexone itself in presence of traces of manganese ions as catalyst. Extinction values obtained somewhat lower than the corresponding values for chromium originally in the trivalent state, but they are reproducible, and true concn. of chromium can be detd. from curves constructed by anal. of std. solns.—*W.P.A.*

Potentiometric Titration of Fluorides. II. S. T. TALIPOV & I. L. TEODOROVICH. Zavod. Lab. (U.S.S.R.), **15**:1031 ('49). Potentiometric detn. of fluorides by formation of the difficultly soluble aluminium salt instead of the iron salt as described in Part I studied. Ferri-ferro-electrode used as indicator, as iron-fluorine complex, Na_3FeF_6 is more soluble than corresponding aluminium cryolite. At temps. below 30°C., 38–160 mg. of sodium fluoride can be deted. with accuracy of $\pm 0.9\%$. Approach of sharp fall in potential at the equivalence point can be noticed, and transition from formation of aluminium complex to that of iron clearly observed. When aluminium deted. potentiometrically by a std. soln. of sodium fluoride, errors from the transformation of some aluminium ions to inactive form avoided. Sulfate ions in concns. corresponding to satn. of soln. with sodium sulfate interfere with titration but bromide has no effect at any concn. —*W.P.A.*

Microchemical Detection of Nitrites and Nitrates. V. HOVORKA & L. DIVIS. Coll. Trav. chim. Tchecosl (Czech.), **14**:495 ('49). In a method for microdetection of nitrite, one drop of soln. to be tested is placed in microcrucible and treated with one drop of dil. acetic acid. Crucible immediately covered with watch glass on underside of which has been placed a drop of soln. of diphenylamine or benzidine acetate or wet strip of starch iodide paper; these change color in the presence of nitrous gases liberated by acid. Iodide, sulfite, thiosulfate, sulfide, permanganate, ferrocyanide and vanadate which interfere can be removed as insol. salts by addn. of silver sulfate. Nitrates may be detected by this method if first reduced to nitrite by treatment with zinc dust and sulfuric acid nitrites in concns. of 10 ppm. and nitrates in concentrations of 100 ppm. may be detected.—*W.P.A.*

Determination of Hexametaphosphate in Water After Threshold Treatment. R. G. YOUNG & A. GOLLEDGE. Ind. Chemist (Br.), **26**:13 ('50). Quant. of sodium hexametaphosphate in water after threshold treatment may be detd. by converting metaphosphate into orthophosphate by boiling in dil. sulfuric acid, and estg. orthophosphate by std. colorimetric method based on the reduction of ammonium phosphomolybdate by stannous chloride. Some alk. industrial waste waters might interfere with this test by neutralizing acid in ammonium molybdate soln. Tannis may cause coloration even in absence of phosphate, but can be removed by treatment with charcoal. No interference is caused by silica to 700 ppm., calcium and magnesium to 1,000 ppm., or nitrates to 100 ppm. Ferric iron above 5 ppm. and titanium above 20 ppm. give greenish color, which may interfere with detn.—*W.P.A.*

Field Chemical Examination of the Waters in Tennessee Streams. C. S. SHOUP. J. Tenn. Acad. Sci., **25**:4 ('50). In relation to maint. of satisfactory conditions for aquatic organisms in surface waters in the Tenn. chem. and phys. anals. of major streams have been made and results given in tables. Effects on aquatic organisms of temp. variations and in contents of B.O. and carbon dioxide and natural factors affecting alky. and pH value discussed. Methods of anal. used briefly described.—*W.P.A.*

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Analysis and Kinetics of Sodium Hypochlorite Solutions. A. Skrabal. S. B. Akad. Wiss. Wien, II b (Austria), **150**:39 ('41). Author discusses various methods for detg. available chlorine and other constituents of solns. of sodium hypochlorite, including Pontius method (titration with potassium iodide in the presence of sodium bicarbonate), Bunsen method and hydrogen peroxide method in which the oxygen evolved is measured or excess peroxide is detd. with potassium permanganate. Kinetics of reactions involved in these methods discussed.—*W.P.A.*

Tropaeolin Method for Determining Hardness of Water by Means of a Simple Colorimetric Scale. I. Y. Sokolov & A. I. Komarova. Zavod. Lab. (U.S.S.R.), **13**:753 ('47). Authors have prepared scale of std. colors to simplify detn. of water hardness by method based on decoloration of Tropaeolin 00. Six std. samples prepd. for testing hardness up to 7 deg. For degs. of hardness between 7 and 16, double the amount of Tropaeolin is added, and when hardness is between 16 deg. and 32 deg. sample is dild. in 1:1 ratio.—*W.P.A.*

Influence of Some Halogen Salts on Color of Copper Tetrammine Complexes. E. Asmus. Angew. Chem. A. (Br.), **59**:119 ('47). Tests made to det. effect of some halides on the color of tetrammine complex formed when copper is detd. with ammonia, showed that increased absorption caused by sodium or potassium chloride was not great enough to cause serious error in the detn. unless very high concns. of salts were present. With ammonium bromide or chloride, however, errors of approx. 10% may be caused in detn. of copper by the presence of 0.5–2.0 m. concns., particularly when content of copper is less than 20 mg. per 100 cc. —*W.P.A.*

Microchemical Detection of Chlorates and Chloric Acid. V. Hovorka

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& Z. Holzbecher. Coll. Trav. chim. Tchecosl (Czech.), **14**:490 ('49). In new method for detection of chlorate, chlorine dioxide liberated by addn. of concd. sulphuric acid and detected by blue color formed with solns. of benzidine acetate or diphenylamine or with starch iodide paper. Chloride, bromide and cyanide, which interfere, first removed as insol. salts by addn. of silver sulphate, and nitrites destroyed by means of hydrogen azide. Concns. of chlorate as low as 20 ppm. detectable by this method.—*W.P.A.*

INDUSTRIAL WATER SUPPLY

Economic Factors Determining Selection of Water-Treating Equipment for the Brewery and Distillery. J. C. Hesler. *Unpublished paper presented at Conf. of Div. of Water, Sewage and Sanitation Chemistry, Amer. Chem. Soc. (Sept. '50).* Need for proper water treatment in brewing and distillery operations is apparent when varied use of water in these operations is considered. Water forms greatest proportion of raw materials used by breweries and distilleries. It plays extremely important part in qual. of the finished product, since practically all process reactions occur in aq. soln. and are therefore subject to effects of chem. and phys. characteristics of supply. It has a secondary part —almost as important—in brewing and distilling practices, because water qual. affects maint. and operating costs in cooling, bottle washing, boiler feed and other plant operations. Treatment of natural supplies to correct chem. and phys. defects practiced by many breweries and distilleries. Many other plants, new and old, contemplating treatment. It is essential each brewery or distillery select only that equip. which most adequately meets its varied plant water requirements at lowest initial and operating costs. Careful considerations should be given alternative methods of treating particular supply to assure user that chem. defects are being efficiently corrected and finished water will meet most plant requirements at the lowest cost. Demineralization treatment of raw waters to remove all dissolved mineral solids receiving increasing attention by brewers and distillers, partial or complete cation exchange treatment in the acid cycle also being utilized, sometimes with blending back of part of raw water; lime treatment for pptn. of objectionable solids, org. matter and suspended solids in favor in many plants. Evaluation of most suitable methods for treating any particular supply depends not only on raw water's characteristics, but on its physical and biol. nature as well. Some typical raw water conditions encountered by brewer and distiller enumerated, and economics of different treating methods evaluated.—*P.H.E.A.*

Examination of Water and Water Supply Facilities in Ports and on Vessels. Zofia Buczowska. Gaz, Woda i Tech. Sanit. (Poland), **24**:219 (June '50). Discusses procedures adopted by International Sanitary

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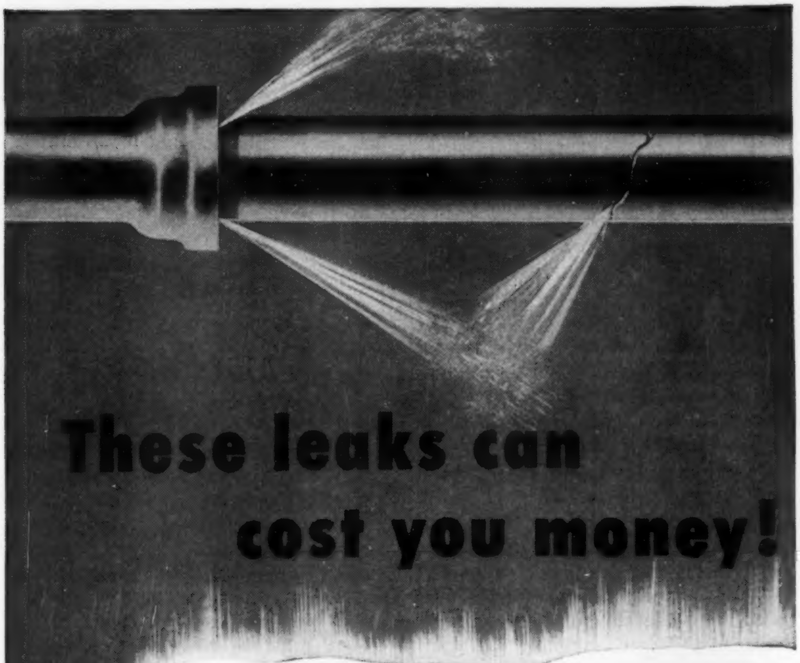
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cost you money!

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Convention for control of port water facilities, for supplying vessels with water, examn. of vessel water-supply tanks, disinfection of vessel water tanks, etc. Frequent examn. of hydrants used as watering points suggested. Water usually taken directly from port hydrants or from water barges which took water from port hydrants. On vessels, water-supply system consists of tanks and distr. system. On larger vessels, activated-carbon filters used for dechlorination. Tanks used may vary in capac. from 3 to 95 tons (1 ton = 1 cu.m.). Chief sources of contamn. reported to be [1] contamd. supply which does not meet drinking water stds., [2] unsanitary loading facilities, [3] defects in tanks and distr. system on ship and [4] lack of disinfecting agents in water. Vessel water supplies examd. in Gdynia, Poland, and approved if met following criteria: [1] no coliform present in 50-ml. samples, [2] total count on agar less than 200 organisms and [3] total count on gelatin less than 1000 organisms. Differentiation of coliforms not practicable because results desired as soon as possible, and ships in port usually only for very short periods. If bact. results showed unsatisfactory water supplies aboard ship, tanks and distr. systems chlorinated. In first series of examns., 60% of supplies unsatisfactory; followup anals. reduced to 42%. Rotterdam Lloyd Lines chlorinate vessel water supplies by addn. of 0.7–1.25 ppm. free Cl_2 followed by dechlorination through activated-carbon filters. Procedure found satisfactory even on long trips. Examn. of 78 specimens of coliform group showed that 19, or 24%, consisted of *Esch. coli;* 31, or 39%, of *Aerobacter* and *E. freundii;* remaining 28 specimens indeterminate. Data show *Esch. coli* contamn. of sufficient frequency to serve as possible source of intestinal disease. Conclusions reported: [1] hydrants serving vessels should be examd. frequently to ascertain that they are in sanitary condition to serve as sources of water supply for vessels, [2] most frequent source of contamn. due to unsanitary techniques of loading water, [3] intestinal coliforms found about 25% of time where coliform group indicated and [4] bact. examn. of tank waters for coliform group sufficient to indicate tank contamn.—*C. P. Straub.*

Survey of Current Practice in Treatment of Cooling Water. DURANDO MILLER. *Unpublished paper presented at Midwest Power Conf. Chicago, Ill. (Apr. '50).* Increased attention recently focused on treatment of industrial cooling water, due to shortages necessitating max. reuse, and limited availability of alloys for cooling systems. Tremendous quants. pumped through heat exchangers and condensers to pick up heat in refinery and chem. processes and in steam plants. Water must be cooled before reused. Cooled by passing through huge wooden towers where heat is removed by evapn. of portion of water. Evapn. of only 1 gal. will reduce temp. 10°F. per 100 gal. of water. Most of circulating water thus available for continuous reuse. As evapn. occurs, minerals remain behind and increase in concn. Unless proper treatment is provided, water hardness coats heat exchange surfaces with scale, which acts as an insulator and lowers eff. Water softening by zeolite or lime process widely practiced to elim. scale difficulties. Prevention of all scale may introduce different problem—corrosion due to oxygen from air absorbed by water in passing through the cooling tower. Copper and stainless steel alloys will resist such corrosion, but critical shortages during World War II forced many plants to use steel heat exchangers. Means therefore perfected to protect steel surfaces against corrosive attack. One method consists of partially softening water and using

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remaining hardness to form a thin scale acting as a barrier between steel and oxygen. Other methods involve use of chem. corrosion inhibitors or removal of air under vacuum. Dirt and slime-forming organisms as unpopular in cooling water as in drinking water and removed by methods similar to those in municipal treating plants. Water treatment engrs. also give attention to wood parts of cooling tower, since they are susceptible to attack by highly alk. waters and also may experience rotting from fungus. Many variable factors influence selection of cooling-water treatment, such as type of water available, heat exchange materials, cooling tower performance, water temps. and flow rates. Careful study of operating experiences at many plants using various treatment methods serves as check on theoretical calculations of the water treatment engr.

The Development of Organics in Water Treatment. J. A. Holmes. *Unpublished paper presented at Midwest Power Conf., Chicago, Ill. (Apr. '50).* Various organic materials have been used for many years to prevent scale and corrosion caused by industrial water. Easily available org. material such as tannins, starches and other plant extracts used. Were satisfactory until some time in the '30's when higher boiler pressures and water temps. necessitated better org. materials. First necessary to try to det. active constituents of orgs. that produced results. Some found better for certain uses such as corrosion, whereas others better for preventing deposits inside boiler. Various uses of orgs. classified, and some have been selected according to particular value for specific uses rather than using one material for all purposes. Since the late '30's, much emphasis put on developing orgs. that are stable under high temps. and give better results. Requirement necessitated altering and changing past available orgs. and developing new synthetic materials. Methods of how this research was done described. No effort made to show examples of plant results, but only to describe manner in which research on org. materials has been done to date.

Transparent Ice. P. Konoplev. Kholod. Tekh. (Poland), **26**:3:34 ('49). Ice used in food should be transparent, and the content of iron oxide in water used should be less than 0.04 mg. per l. Recommended procedure is to add 30–40 mg. of calcium oxide per l. to render water alk. and 40–75 mg. of aluminium sulfate per l. as coagulant. Ice should have bluish tint.—*W.P.A.*

Sanitation Practices for Location, Construction and Maintenance of Drinking Water Wells and Pumping Equipment. H. M. Schudlich et al. Am. Ry. Engrs. Assn. Bul. **490**:230 (Nov. '50). Very complete report with illustrations showing proper sanitary protection to be used for various types of drinking water well constr. with recommendations for handling disinfection and maint.—*R. C. Bardwell.*

Federal and State Regulations Pertaining to Railway Sanitation. H. W. Van Hovenberg et al. Am. Ry. Engrs. Assn. Bul. **490**:224 (Nov. '50). Railroad representatives participating in prepn. of Handbook on Servicing Area Facilities and Operation. The A.A.R. sanitation research project has been completed and facilities moved from Baltimore to A.A.R. research center in Chicago.—*R. C. Bardwell.*

Wayside Treatment for Steam Generator Water. Anon. Ry. Age, **123**: 39 (Aug. '50). Lehigh Valley Railroad replaced individual chem. feeders for treating water used in 3,000-lb.-

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per-hr. steam generators on passenger diesels with four wayside plants where treatment is supervised by lab. technicians. Improved results reported.—*R. C. Bardwell.*

New Water-Treating System Produces Carbon Dioxide-Free Steam. LEO F. COLLINS & ERNEST E. DUBRY. Combustion, **21**:8:47;9:35 ('50). Carbonate-bearing feedwater first softened with zeolite, then acidified and stripped of CO_2 and O_2 in degasifying heater and finally neutralized with caustic. System produces steam contg. such small amts. of CO_2 and O_2 that neither can be measured accurately with most exacting anal. techniques known. Treated water contains less than 0.005 ppm. of O_2 and less than 0.1 ppm. of CO_2. Data on performance of system, operating costs and maint. procedures presented.—*C.A.*

Water Treatment for Ice Making. ARTHUR C. EMBSHOFF (*to Infilco, Inc.*) *U.S. 2,528,875, Nov. 7, '50.* Clear raw-water ice, resistant to cracking, may be frozen quiescently, within the temp. range 6–9°F., without core pulling, by first pretreating raw water, as usual, with alum and lime for economical removal of turbidity and precipitable carbonates, then demineralizing, using the hydrogen cycle for cation exchange, and degasifying. A highly basic anion exchanger is preferable to remove free CO_2 and SiO_2. When raw water carbonates are low, freed CO_2 is removable by forced draft aeration and vacuum deaeration. Freezing cans filled from the bottom without splash to reduce reaeration.—*C.A.*

CORROSION AND CORROSION CONTROL

Water Corrosion Prevention by Sodium Silicate. ANON. Wtr. and Wtr. Eng. (Br.), **55**:246 (July '51). Addition of sodium silicate to corrosive waters inhibits attack on certain metals. First proposal for protection of large water systems in this way was made in '22 by Thresh. In intervening years in America, much interest shown in method. In England, interest not so marked. Originally considered that negatively charged silica micelles were attracted by positively charged metal ions at metal surface, where they coalesced into larger aggregates to form protective silica film. Now believed silica reacts with first products of corrosion to form protective film of metal silicate of low soly. at surface. Sodium silicates commercially available in which weight ratios of soda to silica vary between $Na_2O:3.65SiO_2$ and $Na_2O:0.18SiO_2$. Thresh suggested 8 ppm. SiO_2 as suitable dose, and subsequent experience indicated this to be min. addn. which will form protective film in reasonable time. If silicate is applied in liquid form any std. proportioning device which gives feed rate proportional to flow rate satisfactory. If silicate is being used in form of glass, bypass dissolver forms suitable means of application. Process eff. in controlling corrosion of many metals and valuable in protection of pipelines of various corrosive metals. Three methods of detg. degree of protection obtained are: [1] D.O. detn.; when corrosion is taking place D.O. is reduced in approx. proportion to amt. of corrosion taking place; [2] metal detn.; once system is in equil. anal. before and after passing water through system forms reliable appraisal of protection; [3] examination of pipe; carry out examn. of pipelines from time to time. Types of systems in which silicates can be used are: [1] industrial supplies, [2] semi-industrial supplies and [3] domestic supplies. Using liquid silicate, cost approx. 0.15d per 1,000 gal. (Imp.) of water treated, and is independent of water qual. If silicate glass is used, cost approx. 0.06–0.07d per 1,000 gal. (Imp.).—*H. E. Babbitt.*

The Reading Meter

(*Continued from page 20*)

The Water Situation in the United States With Special Reference to Ground Water. C. L. McGuinness. *Circular 114, Geological Survey, Washington 25, D.C. (1951) free*

This report constitutes Appendixes B and C to a report prepared by the Geological Survey for the President's Water Resources Policy Commission. The full report, entitled "Water Facts in Relation to a National Water-Resources Policy," included a brief text and Appendix A by A. N. Piper, and those portions are to be published separately.

With the Geological Survey's usual penchant for getting down to essentials, the report leads off with a layman's explanation of the hydrologic cycle and then proceeds to a discussion of the effects of land and water-use practices upon ground water, its relation to the national economy and the interest of the federal government in water resources. For the professional water works man, the most valuable section of the report will be the detailed survey of the current water supply situation, which is contained in a section of Appendix B and, in tabular form, in Appendix C. Together these sections comprise nearly 150 pages of concise, factual information on the status and adequacy of the country's water supplies.

Irrigation Engineering. I. Agricultural and Hydrological Phases. *Ivan E. Houk. John Wiley & Sons, Inc., New York (1951) $9*

On the borderline of interest to most Journal readers, this volume nevertheless contains much hydrological information which is basic and valuable to the entire water supply field. Specifically, chapters are devoted to soil-moisture movements, climatic factors, runoff and stream flow and snow melting and runoff forecasting. The second volume of the series will be devoted to project planning and structures.

Malvern J. Hiler, executive vice-president of Commonwealth Eng. Co. of Ohio, has been made president of the firm. After association with various chemical firms, he came to Commonwealth, and occupied the vice-presidential post for the past three years.

Service Lines

Copper and copper-alloy die-pressed forgings are the subject of a booklet just issued by the American Brass Co., Dept. DPF, Waterbury 20, Conn.

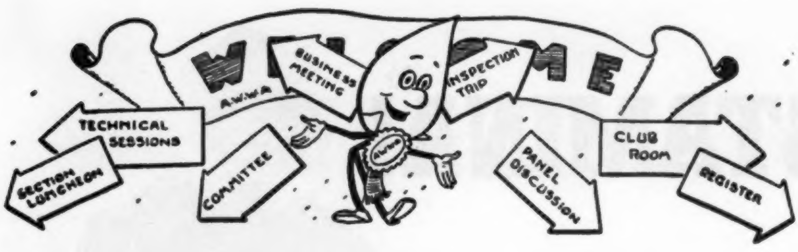
The use of plastic electrical tape as an insulating, anticorrosive pipe wrap is discussed in a circular distributed by Minnesota Mining & Mfg. Co., 900 Fauquier Ave., St. Paul 6, Minn.

Packaged electric power units for industrial expansion are described and installation procedures for them illustrated in a new 24-page bulletin—GEA-5600—available from the General Electric Co., Schenectady 5, N.Y. A checklist of other bulletins on equipment available from the company is included.

Water hammer in piping systems is the subject of an 8-page bulletin distributed by the Williams Gauge Co., 1620 Pennsylvania Ave., Pittsburgh 33, Pa. The use of silent check valves to avoid water hammer effects is also described.

A cleaner for chlorine feeders is the subject of a circular distributed by Lake Products Co., 6576 Oleatha St., St. Louis 9, Mo. It is claimed to be a safe and noninjurious agent for the removal of gums, waxes, chlorine hydrate and other impurities and accumulations.

A folder describing Penfield Mfg. Co. water conditioning equipment may be obtained from the company, 19 High School Ave., Meriden, Conn. Demineralizers are featured.



Section Meeting Reports

Michigan Section: The thirteenth annual meeting of the Michigan Section was held at the Whitcomb Hotel in St. Joseph-Benton Harbor on September 19–21. The twin cities, located on the picturesque shores of Lake Michigan, provided a most enjoyable location for the meeting. These natural beauties, combined with "well planned" weather and perfect hosts, helped to make for a very successful meeting. A total registration of 284 including 59 ladies set a record for the section.

One of the highlights of the meeting was a description of the design of the new Benton Harbor water filtration plant by Paul H. Johnson, a member of the consulting firm of Consoer, Townsend and Associates, and an inspection of the plant. William Russell gave a graphic description of his operating experiences with the new plant. The many new and modern features of the plant—such as solids-contact clarifiers, modern building design, solenoid-operated hydraulic valves for filtration control, deluxe appointments, chlorine residual recorder and fluoridation equipment—provided a most interesting inspection trip.

The sun deck beneath a starlit sky and overlooking the beautiful St. Joseph River and Lake Michigan was the scene of the club room entertainment provided so graciously by the manufacturers representatives through the Water and Sewage Works Manufacturers Association.

The annual banquet held on Thursday night will long be remembered by the group. Greetings were presented by A.W.W.A. President A. E. Berry and Commissioner A. E. Heustis of the Michigan Dept. of Health. Walter E. Gries of the Cleveland Cliffs Iron Co. spoke on "The Joy Free Men Know." He related many interesting tales of the people who populate the northern peninsula of Michigan, the "original" land of Paul Bunyan.

An annual feature at the banquet is the presentation of the Edward Dunbar Rich Service Award to persons completing 25 years of meritorious and faithful service in providing and maintaining a safe and adequate water

(*Continued on page 78*)


Pekrul
Gates
PEKRUL MODEL 56 GATES with Philadelphia Limitorque Model M30 Motorized Lifts in operation at Denver Sewage Disposal Plant.
PEKRUL GATES are engineered to meet the most rigid requirements for:
Flood Control
Levees
Irrigation
Water Works
Dams
Sewage Disposal
Reservoirs
Pumping Plants
Oil Refineries
Fish Hatcheries
Rearing Ponds
Recreation Pools
Cooling Towers
PEKRUL GATE DIVISION
MORSE
BROS. MACHINERY CO.
DENVER, COLORADO
Write for Catalog 49

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supply in Michigan. These awards were presented by John M. Hepler, director of the Div. of Engineering, Michigan Dept. of Health.

The Thursday morning program was devoted to water supply problems occasioned by air conditioning and refrigeration. Frank C. Amsbary Jr. of the neighboring Illinois Section presented the point of view of the water works. His pleasant personality and admirable presentation of the subject made a permanent impression on the members. A. E. Stacey Jr. of the Carrier Corp. presented the problems of industry, and Hugh E. Keeler of the University of Michigan analyzed "Power and Water Demands."

The Thursday afternoon session heard such topics as "Air Navigation Hazards From Elevated Structures" by Lindell D. Hale of the CAA and "Water Supply as It Affects Fire Protection" by R. C. Loughead, chief engineer of the Michigan Inspection Bureau. A paper by Feben and Taras and discussion by Faber and Hedgepeth discussed studies of chlorine demand constants.

The closing session heard Raymond J. Faust discuss "National Supply Problems and Procedures for Securing Critical Materials." Now A.W.W.A. executive assistant secretary and formerly with the Michigan Dept. of Health, he again proved himself a real part of the Michigan Section to which he has contributed so much over the years. John Dye of the Lansing Water Conditioning Plant gave a paper on the "Calculation of the Effect of Temperature on pH." A paper on "Safety Practices" by George McDonald of the National Safety Council was followed with a discussion by Lynn Erratt of Lansing and Earl E. Norman of Kalamazoo. The challenge presented by these authors resulted in a motion by the section to study the safety problems in Michigan.

The very interesting ladies' program will leave many happy memories of the twin cities. Tours to many points of interest in the heart of the fruit center of the world proved to be most enjoyable. "Sweden's Hindmost Authority on Fashion" gave a preview on coming fashions in hats from sprinkling can models to flapjack varieties. The ladies' program has proved to be a very necessary part of the annual meeting.

T. L. Vander Velde
Secretary-Treasurer

Pennsylvania Section: The Pennsylvania Section held its third annual meeting September 19–21, 1951, at the Bellevue-Stratford Hotel in Philadelphia. The total attendance was 214, including members and guests.

The technical sessions opened with Chairman T. H. Kain presiding, and E. T. Davis substituted for D. E. Davis in presenting "Improvements to Erie Filter Plants." A symposium on "Industrial Water Supply Qual-

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For—
repairing
broken
cast iron
mains

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ity, Conservation and Control" followed, led by L. L. Hedgepeth of the American Cyanamid Co., Bound Brook, N.J. The general phase of the subject was covered by Roy R. Green, National Assn. of Manufacturers, New York. A paper by Robert W. Haywood Jr., E. I. DuPont de Nemours & Co., Wilmington, Del., discussed "Conservation and Control," and a paper by G. A. Howell, assistant to the chief engineer, Manufacturing Division, U.S. Steel Co., Pittsburgh, discussed "Water Supply for the U.S. Steel Co. Plant at Morrisville."

Before the technical sessions began, two motion picture films, entitled "Trenton Cleans Its Water Mains" and "Washington Cleans Its Water Mains," were shown to the audience through the courtesy of National Water Main Cleaning Co. The first session concluded with a business meeting, at which time reports of committees were presented.

The technical session on Thursday morning was opened by L. D. Matter, trustee of the section, who presided. "Waters of the Commonwealth," a film prepared by the Pennsylvania Dept. of Health, showed the progress being made in stream pollution abatement. Another film, made and furnished by the General Electric Co. and entitled "Pipeline to the Clouds," was shown to the audience in the first release of this film in the Philadelphia area to a public audience.

The subject of civilian defense was presented from a statewide level by Richard Gerstell, state director of civil defense, and a companion paper on "Civil Defense for Water Supply" was presented by John H. Murdoch Jr. of the American Water Works Service Co., Philadelphia. Joseph G. Filicky of the West Virginia Pulp & Paper Co., Tyrone, Pa., discussed "Factors Influencing the Efficiency of Activated Carbon," and Martin E. Flentje, of the American Water Works Service Co., Philadelphia, followed with an excellent paper on "Algae Control in Reservoirs."

A luncheon was held Thursday at noon, at which time Charles H. Capen, A.W.W.A. vice president, addressed the gathering.

The Thursday afternoon session began with J. D. Johnson, vice chairman, presiding, and the first subject discussed was "The Delaware River Basin Water Project," presented by Francis A. Pitkin, chairman of the Interstate Commission on the Delaware River Basin. "Priorities of Water Works Materials" was presented by Harvey Howe, former director of the Water Resources Div., National Production Authority, Washington, D.C., and ably discussed by James G. Carns Jr. of the American Water Works Service Co. of Philadelphia. A symposium on "Water Purification" was presented, with H. F. Holloway, manager, Midland Water Co., Midland, Pa., discussing the Ohio River; a paper by E. C. Goehring, assistant manager of the Beaver Valley Water Authority, Beaver Falls, Pa., on the Beaver River; a discussion by Frank Bouson, chief chemist of the

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South Pittsburgh Water Co., Pittsburgh, on the Monongahela River; a presentation by John F. Kegebein Jr., chemist, Norristown Water Co., Norristown, Pa., on the Schuylkill River; and a final discourse on the Delaware River by Elwood Bean, principal assistant engineer, Bureau of Water, Philadelphia.

The afternoon business session was devoted to the report of the Nominating Committee and the election of officers for the ensuing year. A motion was also passed at the business session to appoint a committee to consider the matter of civilian defense for water works throughout the state.

The annual banquet was held on Thursday evening, with an attendance of 150 members and guests. Vice President Capen brought the greetings of the Association in a short talk to the audience. A program of entertainment featured the wizardry of Kenneth E. Shull, a section member connected with the Philadelphia Suburban Water Co., who was ably assisted by his wife and several participants in the audience. The Kistler Family, a vocal combination of husband, wife and two sons, presented a fine musical program, which was much appreciated by the audience. L. S. Morgan then presented the Fuller Award Committee's 1951 nominee, Earle Phillips Johnson, district manager of Wallace & Tiernan Co., Inc., of Pittsburgh, wth the citation: "To Earle Phillips Johnson for the genial, tactful and devoted service which he has rendered the water works profession and for his untiring efforts on behalf of the Association in connection with his many years of service as Secretary-Treasurer of the Western Pennsylvania Section."

On Friday morning, the session was presided over by Francis S. Friel, Chairman of the Program Committee and the newly elected trustee of the Section. The first discourse was an excellent presentation on the subject of "Water Hammer and Surge Suppression in Pipelines" by S. Logan Kerr, consulting engineer of Philadelphia. "A Review of the Report of the Presidential Water Policy Commission" was presented by Gilbert White, president of Haverford College, Haverford, Pa. The concluding paper was given by W. James MacIntosh of the firm of Morgan, Lewis and Bockius, counselors at law of Philadelphia, on the subject of "Rates for Water Service."

The Water and Sewage Works Manufacturers' Assn. provided entertainment for a get-together Tuesday evening preceding the convention, and also for social hours Wednesday afternoon and Thursday evening prior to the banquet.

The Section unanimously adopted a resolution favoring the proposed project for the conservation of the water resources of the Delaware River Basin, as formulated by the Interstate Commission on the Delaware River

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Basin, and urging the Governor of Pennsylvania and other officials charged with the duty of appraising the proposed Delaware River Basin project to conduct their investigations with the utmost dispatch, with the underlying objective of maintaining cordial and cooperative relationships with the other states in which the Delaware River Basin is located and thus set a desirable pattern for the establishment of a sound national water policy.

L. S. Morgan
Secretary

Kentucky-Tennessee Section: The twenty-third annual meeting of the Kentucky-Tennessee Section of A.W.W.A. was held jointly with the Kentucky-Tennessee Industrial Wastes and Sewage Works Assn. at the Kentucky Hotel, Louisville, Sept. 17–19, 1951. The total registration of 220 included 46 ladies.

Following registration the joint session opened with an address of welcome by Henry Gerber, president of the Louisville Water Co., and response by G. R. Kavanagh, Wallace & Tiernan Co., Knoxville, Tenn. The presidents of each of the national organizations bring greetings and point out some of the advantages of cooperation between the two states and two organizations. Also the importance of water, sewage and industrial waste problems in relation to the present world situation and to the economy of the country was emphasized.

The afternoon session included a discussion of the formation of a Utility District at Old Hickory, Tenn., by H. B. Richards, chairman, Board of Commission of that town, a talk on Civilian Defense Emergencies by Neil Dalton, coordinator, Louisville Area Civil Defense Advisory Committee, Louisville, Ky., and a discussion of Tennessee and Kentucky water supplies by Carl L. Sebelius, director, Dental Hygiene Service, Tennessee Dept. of Public Health, and H. N. Jernigan, Wallace & Tiernan Co., Union City, Tenn. The afternoon session was concluded by a talk on management of a water company by A. E. Clark, manager, Nashville Suburban Utility Dist., Nashville.

The separate A.W.W.A. session on Tuesday included panel discussions followed by questions and answers on the following subjects: obtaining technical services for small water systems; service installations and tapping cement, asbestos and cement-lined pipes; how fire rates are set; benefits of water works short courses to plant management; policies of providing water service beyond city limits; and effects and cost of state highway construction policies on utility installations. All of these panels were led by water works men and as in the past proved to be the most valuable part of the technical program. The technical program was concluded with a joint session on Wednesday morning with a paper on Plan-

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ning the Expansion of Water and Sewerage Service by Arthur L. Dow of Paris, Tenn., followed by inspection trips to various units of the Louisville Water System.

Entertainment was provided at a dinner Monday evening (courtesy of Louisville Water Co.) and the annual Dinner-Dance Tuesday evening. Special entertainment for the ladies included a luncheon and style show on Monday and a luncheon followed by visits to points of interest on Tuesday.

R. P. Farrell
Secretary-Treasurer

Rocky Mountain Section: The Annual Fall Meeting of the Rocky Mountain Section was held in Denver, Colo., September 24–25, 1951, at the Cosmopolitan Hotel. The total registration numbered 128.

Monday morning, September 24, was devoted to registration. Secretary-Treasurer George J. Turre introduced L. F. Leonard, city attorney, who opened the meeting by officially welcoming the delegates, in the absence of Mayor Newton. The meeting was then turned over to Charles G. Caldwell, chairman, who presided. A.W.W.A. Secretary Harry E. Jordan spoke on "The Current Problems of the Water Works Industry."

The Monday afternoon session was presided over by Chairman Caldwell. The first paper presented was on "Fluoridation of Domestic Water Supplies" by F. J. Maier, senior sanitary engineer of the U.S. Public Health Service, Washington, D.C. G. E. Riepe, sales engineer for Builders-Providence, Inc., spoke on "Handling and Feeding Fluorine Compounds." "The Problem of Nitrate-Contaminated Drinking Water" was discussed by Graham Walton of the U.S. Public Health Service Environmental Health Center, Cincinnati, Ohio. The last paper at the afternoon session was delivered by George Schlitt, Public Health Engineer, Colorado State Department of Health, who spoke on "Water Disinfectant Dosages."

Tuesday's morning session was presided over by W. N. Gahr and consisted of the following: "Reservoir No. 22 Dam" by D. D. Gross, chief engineer, Board of Water Commissioners, Denver, Colo.; motion picture, "Pipeline to the Clouds," shown by L. M. Stauffer, District Manager of General Electric Co., Denver, Colo. (see photo); and "Small Water Supplies" by Robert Cameron, environmental sanitation control officer, Denver General Hospital. A business luncheon was held on Tuesday noon.

Tuesday afternoon, with O. J. Ripple presiding, the following subjects were presented: "Biological Warfare" by Dr. John Richty, associate professor, Colorado Medical School, Denver; "Civilian Defense Relating to Water and Sewage Facilities" by Terry Owens, city engineer, Denver; and "Survival Under Atomic Attacks" by Lt. Gen. Henry A. Larson, director, Colorado Civilian Defense Agency, Denver.

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"Round Table Discussion of Problems" concluded the program on Tuesday afternoon. During this discussion Mrs. M. J. Taylor, representing the Corey Boltless Clamp Co. of Los Angeles, introduced a new type of clamp, for use in making tap connections.

The Annual Banquet was held Tuesday evening and was well attended. Dana E. Kepner presided as toastmaster. W. H. Wisely, secretary of the Federation of Sewage and Industrial Wastes Associations, spoke on

"Good Water and Plenty of It" is the concern of this group of Rocky Mountain Section meeting-goers. Left to right are L. M. Stauffer of the General Electric Co., which produced the motion picture and published the booklet; Earl Mosley of the Denver Board of Water Commissioners; A.W.W.A. Secretary Harry E. Jordan; and Section Secretary-Treasurer George J. Turre.

"Public Relations." The guests at the banquet were delightfully entertained by vocal selections conducted by W. N. Newell in which the audience participated. After the banquet, music was provided for dancing.

Ladies' entertainment during the time of the meeting consisted of an auto tour of the city followed by a delightful luncheon at the Aviation Club.

George J. Turre
Secretary-Treasurer

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Minnesota Section: The Minnesota Section, which includes the states of Minnesota and North and South Dakota, held its 35th Annual Convention at the Hotel Nicollet, Minneapolis, on September 12–14, 1951. Including the ladies, there was a total of 183 in attendance.

Ten formal papers were presented, covering such subjects as civil defense, meter shop practices, the fluoridation of water supplies, water softening, and iron and manganese removal. A panel discussion on the relations between water works operators and city officials, a guided discussion on office procedures, and a question and answer period brought forth a large amount of interest and informal participation.

A report by the section committee, which had spent over a year working with committees of the University of Minnesota, the State Board of Health, and the League of Minnesota Municipalities, was presented and approved. It provided for the voluntary certification of water and sewage works operators. The plan provides for a twelve-member board, each member to serve for a 3-year period. For the purpose of certification the State Board of Health will classify all water works in one of four grades, to reflect the degree of treatment required. Correspondingly, four population groups and corresponding grades of operators will be designated.

A.W.W.A. Vice President Charles Capen entered into the spirit of the convention and formally addressed the members at the Thursday noon luncheon. His talk was extremely interesting and very well received.

The program sessions were opened each day with movies, and an inspection trip was included the first day. The ladies in attendance were entertained with luncheons, cards, style show and movies.

The annual banquet, held the closing day, produced entertainment, music and awards. The Fuller Award was voted for Ross A. Thuma, superintendent of filtration, St. Paul, and the newly created Finch Award was presented to C. F. Wimer, superintendent of the Hastings, Minn., Water Dept. Milton Rosen, commissioner of public works, and for many

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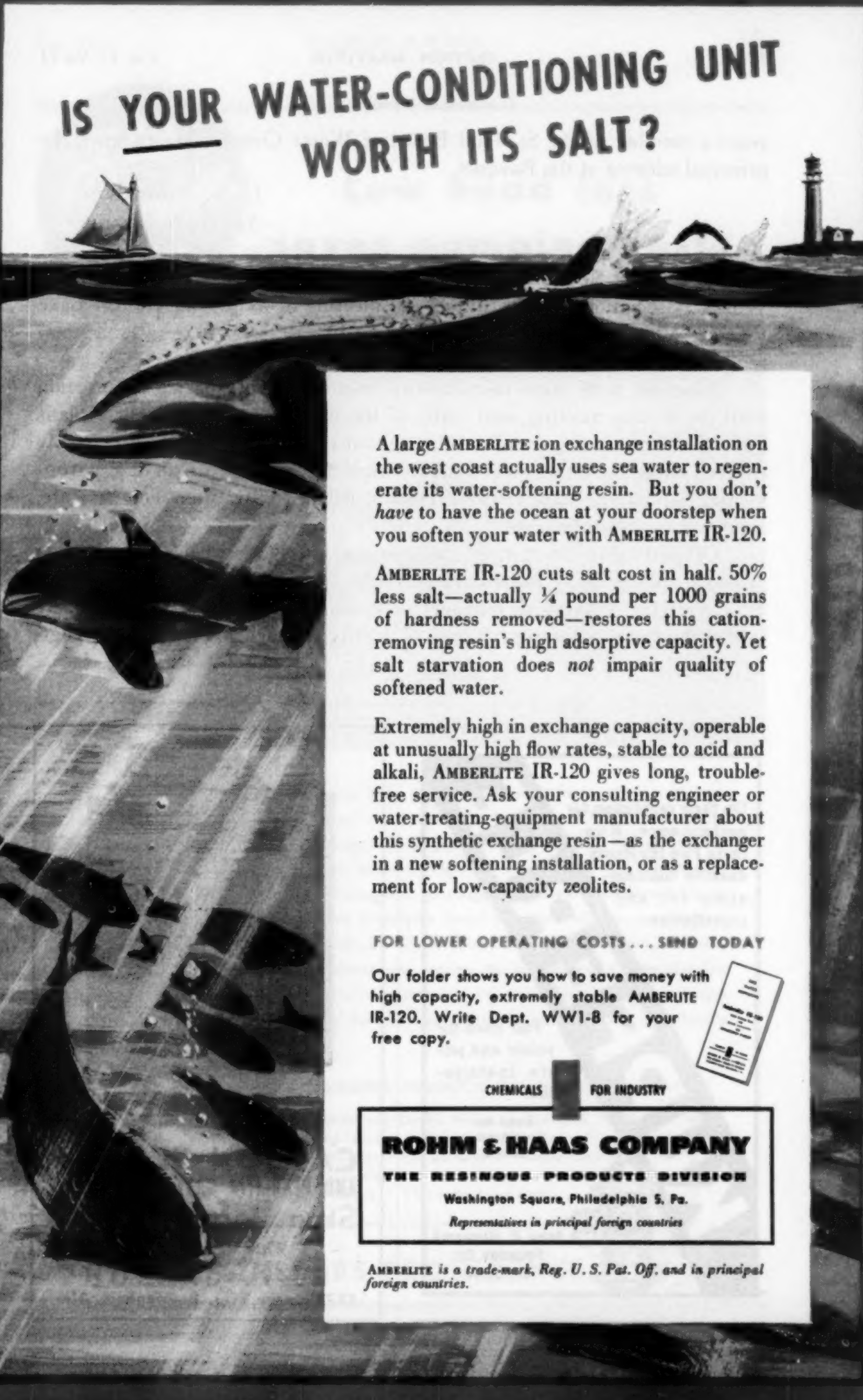
IS YOUR WATER-CONDITIONING UNIT WORTH ITS SALT?
A large AMBERLITE ion exchange installation on the west coast actually uses sea water to regenerate its water-softening resin. But you don't *have* to have the ocean at your doorstep when you soften your water with AMBERLITE IR-120.
AMBERLITE IR-120 cuts salt cost in half. 50% less salt—actually ¼ pound per 1000 grains of hardness removed—restores this cation-removing resin's high adsorptive capacity. Yet salt starvation does *not* impair quality of softened water.
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years a member of the St. Paul Board of Water Commissioners, gave the principal address at the Banquet.

L. N. Thompson
Secretary-Treasurer

New York Section: The New York Section of the American Water Works Association held its annual fall meeting at Whiteface Inn on Lake Placid, Whiteface, N.Y., September 12–14, 1951. There was a total registration of 340.

Nineteen state zone coordinators held their meeting in conjunction with the section meeting, and many of the members attended. The plans for civil defense and mutual aid throughout the state were very thoroughly covered under the direction of Earl Devendorf, director, Bureau of Environmental Sanitation, State Dept. of Health, Albany, with discussion by state, zone and city coordinators.

Of particular interest at the meeting was the panel discussion on "Critical Materials," led by A.W.W.A. Secretary, Harry E. Jordan. T. T. Quigley, advertising manager of Wallace & Tiernan Co., Inc., represented the manufacturerers; James G. Carns Jr., meter and materials engi-

(Continued on page 94)

(*Continued from page 92*)

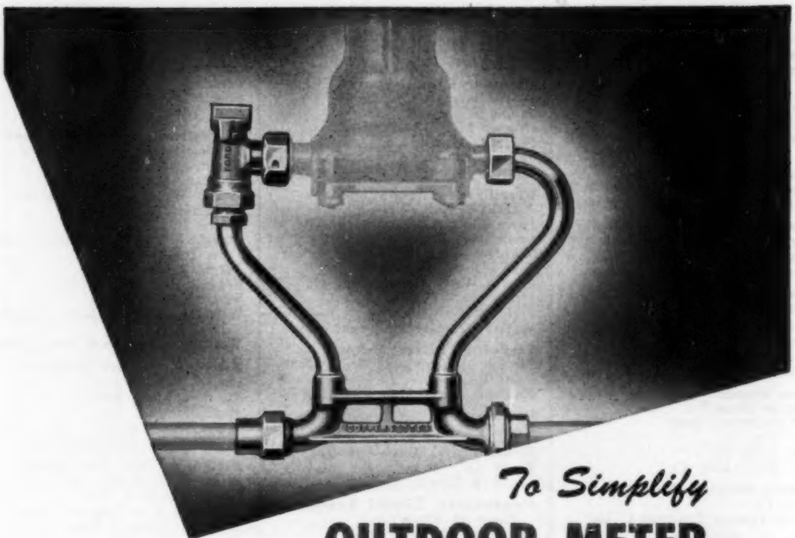
neer of the American Water Works Co., represented Water Works Operators; and Harvey Howe, Director, Water Resources Division, NPA, Washington, D.C., represented the government. There was a thorough discussion of the current rulings and future outlook.

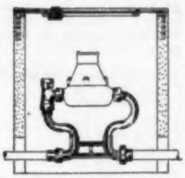
The Incodel Project which involves the joint water supply plans of the states of Pennsylvania, New Jersey, Delaware and New York was discussed, and a resolution favoring the project was adopted. Irving Huie, president of the New York City Board of Water Supply, presented the city's point of view and James C. Harding, chairman of the Water Resources Committee of the New York Section, outlined the plan. Malcolm Pirnie, consulting engineer of New York City, who jointly prepared the complete reports on the Incodel Project, outlined the plan's advantages in detail.

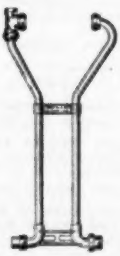
Fluoridation again was thoroughly discussed, and particular emphasis was placed on the matter of the application of fluoridation in water works.

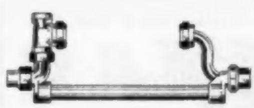
The "Round Table Conference," under the leadership of S. P. Carman, consulting engineer of Binghamton, N.Y., produced the usual provocative questions and answers.

R. K. Blanchard
Secretary-Treasurer









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(See Prof. Services, pp. 25–29)

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(See Prof. Services, pp. 25–29)

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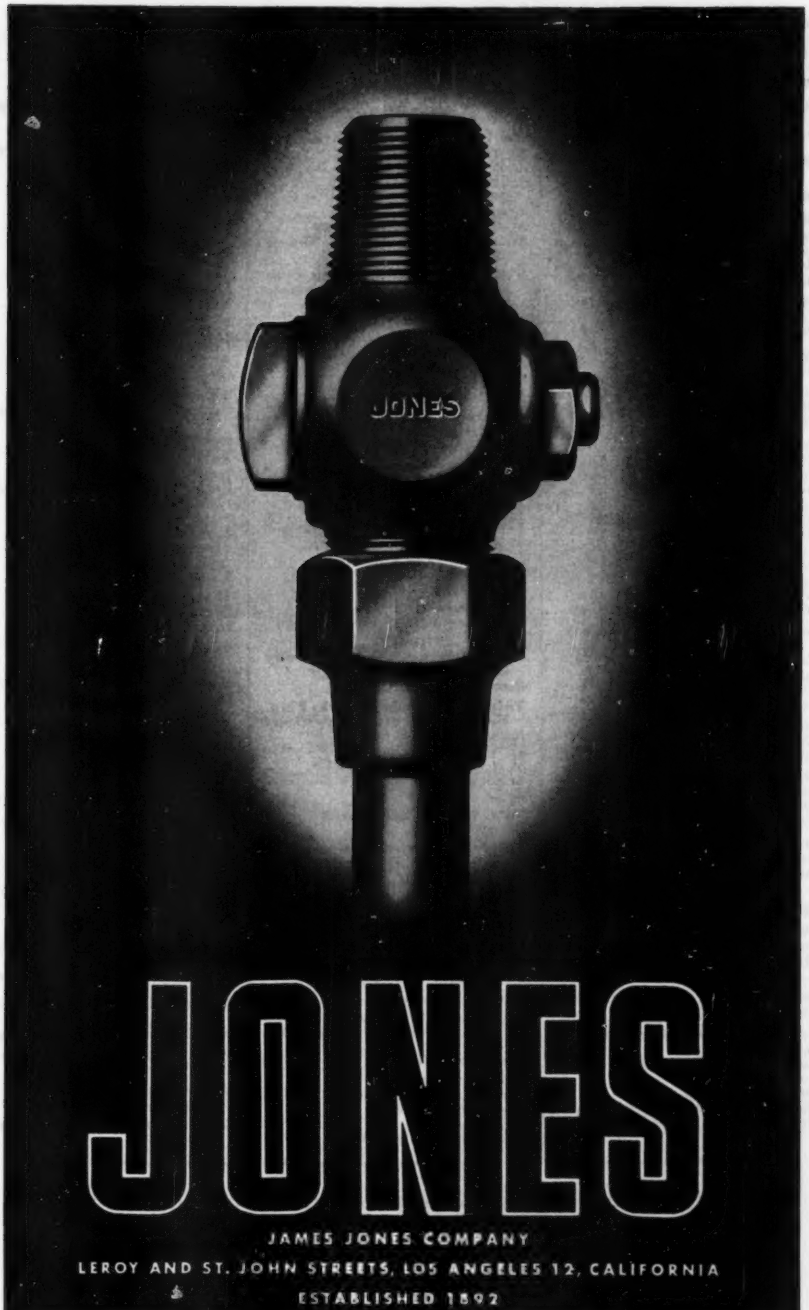
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